TECHNOLOGICAL HANDBOOKS

COTTON WEAVING

R. MARSDEN

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COTTON WEAVING:

ITS DEVELOPMENT, PRINCIPLES, AND PRACTICE.

BY

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PREFACE.

THE following work, which is complementary to the writer's former treatise upon "Cotton Spinning," was designed at the same time, and originally intended to appear at a comparatively short interval thereafter. Events occurred, however, which compelled the author to lay down the task. When resumed it had to be performed simultaneously with the heavy work of conducting a weekly trade journal, "The Textile Mercury." Had the writer not felt in honour bound to the publishers to complete it, it would probably have been abandoned in the face of more important demands. The task is now, however, finished, and he would take this opportunity of acknowledging the great patience and kindness of Messrs. Bell and Sons in waiting, and that without pressure, until circumstances permitted it to be resumed and carried to a conclusion.

The work is sent forth by the writer in the hope and trust that it will contribute to increase the interest of those whose lives, capital, and energies are practically invested in the cotton trade; and whose welfare, and that of generations of their descendants to follow, are inseparably bound up in the conservation of its interests and the promotion of its prosperity. And beyond this class there is another he would desire to affect, namely, those who care something for the great interests of the State. If any one choose to examine the industrial development of the country, thoroughly, and without bias or prejudice, it will be found that its

eminence in almost everything that makes a nation great, originated in and is maintained by its mechanical industries. And of these the cotton trade was the first, thus becoming the foundation stone of its eminence. There is one lesson that should and will be drawn if the history of the cotton trade be read wisely: it is, that the trade does not belong to the merchants, capitalists, and workpeople of the present generation, but that it is a great national property in which they possess only a life interest. This they are bound by every sentiment of affection for their children and love for their country to pass on to succeeding generations, not only unimpaired, but increased in value. To neglect this duty will be to deprive millions of English people in the future of the means of livelihood, and the nation of one of its most important resources. This would be politically criminal and would do much to depose the country from its eminence in the community of nations. There is also a further duty incumbent upon those whose chief interests are connected with this trade. This is to protect it from external aggression, especially that of ignorant legislators, whose capacities for mischief have been so extensively manifested in the Parliament just dissolved. No more important duty can engage attention than that of the critical examination of the legislative projects affecting it brought forward in the House of Commons, and to give strenuous resistance to every one that will act adversely to its well-being.

The present work is an exposition of the development, principles, and practice of the weaving division of the trade, as the former volume was of the spinning division. In its execution the writer has adhered to the plan of the former work, which has received the emphatic approval of all readers interested in the subject. If there be any difference it will be found in the fuller and more careful exposition of the origin and development of the subsidiary processes, and of the invention and improvement of the series of machines employed in this section of the trade. An effort

has been made to clearly define the art of weaving, to trace its development from the primitive germ through all the succeeding stages of its growth to its present wonderful perfection. In the course of the narrative care has been taken to show when and why it has developed tendencies to divide and subdivide, throwing those branches off as separate processes that have become known by other names, though they still are and must ever remain adjuncts of the original parent of the whole, namely, the weaving process. By a careful perusal of what has been written the reader will be able to understand the causes and requirements in which originated not only every part of the loom but of those of almost all the machines employed in the preparatory processes. With this knowledge the intelligent technical reader will easily decide, when further changes or innovations are proposed, whether they are in harmony or conflict with the leading principles embodied in what has already been accomplished, and whether their adoption will prove advantageous or otherwise. All changes are not improvements, and the money spent upon those that are valueless will be simply so much wasted; and the condition of the trade is not such as to admit of waste.

Weaving, of course, is one of the most ancient arts, and cotton weaving in India at least can reckon its history by centuries. In England it is, however, one of the most modern industries, and the development of the English system of manufacturing constitutes one of the most remarkable series of phenomena to be found in human history; and the benefits that have resulted directly and indirectly have seldom if ever been equalled from a single cause. For more than half a century these advantages were almost monopolized by this country, but during the half century which will come to a close in a few years they have been appropriated to a more or less extent by almost every other nation. England can only therefore expect to continue to receive a large share of its benefits by keeping well in front with its inventions and improvements, and for this

she must depend not only upon her present inventors, but upon a further development of the inventive faculty. That this may to some extent be stimulated by the present work is one of the desires of its author.

RICHARD MARSDEN.

MANCHESTER,
August, 1895.

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CHAPTER I.

Introductory.

The division of the cotton trade into two branches, spinning and manufacturing.—India, its birthplace.—Indian processes; the Institutes of Menu.—Indian competition with the English textile industries the origin of the English cotton trade.—Early tendency of the English trade to divide into two sections.—Temporary tendency to reunite.—Reaction and probable permanency of the division.

THE contents of the introductory chapter of the author's previous work on "Cotton Spinning: its development, principles, and practice," obviates the necessity of any lengthened remarks on the present occasion. But in order to enable the student to thoroughly comprehend the subject and the reasons for the ultimate division of the great cotton trade into two sections, a brief review of its development, considered from a somewhat different point of view, will be not only permissible, but necessary.

As observed in the work referred to above, the best historical evidence obtainable points to India as the birthplace of cotton manufacturing; but when it commenced, how long it remained a pure handicraft, or at what date the first rude mechanical appliances were introduced, are details of its history irrecoverably lost in the mists that have gathered around those long-past times. As far back

as ancient records lay bare the history of India, the manufacture of the downy product of the cotton plant is shown to have been generally diffused over that country, employing more or less fully nearly half the population. To quote from the chapter referred to in my previous work: "Cotton was grown in the districts closely adjacent to nearly every village; cleaned, spun, and woven on the spot; each little community producing enough for its own consumption. A rudely constructed roller gin separated the seed from the fibre, and the latter was cleansed from the leaf, dirt, and knots by the bow. The cotton, as left by this instrument in a light fleecy mass, was then taken and, with little further preparation, spun by the women." It will be safe to infer that for a long period the only instrument employed was the rude spindle, and mostly without the distaff, the worker drawing the cotton from loose, fleecy balls, into which it had been formed. Down to recent times, this system of hand spinning has existed side by side with that of the rude wheel still employed for the purpose. The industry being a purely domestic one, was conducted through all its processes and details by the members of one family in their dwellings, or adjacent thereto in the open air. The portions of the processes analogous to those of our present manufacturing system are what mainly concern us and require notice here.

The Indian weaver receives his yarn from the native spinner, as well as from the Indian and European mills, in the bundled form, or in knots or hanks. In this form it is taken and transferred to a pyramidal reel, and thence wound upon short pieces of reed for use in the next process, that of forming the warp. This is done on the plan called peg-warping, not many years extinct even in this country, which will be described in the proper place subsequently. The warp was sized in the most primitive fashion by means of rice water, and it is a curious fact that even in the earliest times malpractices in sizing were

not unknown. The Institutes of Menu, compiled a thousand years before the Christian era, condemn heavy sizing, and declare that a proper allowance shall be made for the added weight, even when sized only for weaving. In Chap. VIII. v. 30, there is the following passage regarding the practice of sizing: "Let a weaver who has received ten palas of cotton thread give them back increased to eleven by the rice water and the like used in weaving. He who does otherwise shall pay a fine of twelve panas." This ancient legislator clearly entertained the idea that sizing should be confined to the legitimate use of rendering the warp more easily workable, and that all beyond should be prohibited. It is questionable, however, whether much more regard was paid to this injunction than is to-day given to moral principles in relation to the same matter.

India from the earliest times exported its cotton manufactures to the countries of Western Asia, whence they were distributed to those of Europe lying along the basin of the Mediterranean, and sometimes to the lands beyond these, though this was but rarely. It was not until after the discovery of the Cape route to the East that the real influence of the manufactures of India upon the Western countries of Europe began to make itself felt. The comparatively low prices at which they now came to be attainable, and their great beauty, caused them to become highly esteemed amongst the aristocracy and the wealthy classes of this country, to the great neglect of the coarse fabrics of home production composed of wool and linen. During the closing years of the seventeenth century, and the opening ones of the eighteenth, the outcry raised against the use of the Indian fabrics led to the passage of several Acts of Parliament having for their object the protection of the native industry. In spite of these, however, Indian goods continued to be worn, and no real or permanent impression was made in the restriction of their use until the weavers of England began to imitate them,

which was done in fabrics composed of a linen warp and cotton weft, the English spinners, with their appliances and previous training, being incapable of making a warp yarn from cotton. These productions for a time satisfied the growing popular demand for light fabrics. The true Indian cloths, however, continued to be extensively worn by the upper and wealthier classes.

At this period the earliest symptoms of a separation of the cotton trade into the two branches of spinning and manufacturing began to appear. The invention of Kay's method of throwing the shuttle, called the picking stick and fly shuttle, in 1733—not 1738, as so often given by writers on this subject—had so increased the capacity of the weaver that the members of his own household were rarely sufficient to provide him with the yarn necessary to keep him at work. The demand for yarns became so strong, that in households where no weaving was carried on the younger members were taught to spin, and in a short time, by their earnings, added very considerably to the income of the family. The subsequent invention of Hargreaves' spinning jenny accentuated and increased this movement towards separation, as families whose occupation was mainly spinning, as well as those engaged in weaving, procured the new machines. We thus discover at this early stage the tendency of the industry to separate into the two divisions into which the progress of invention and the development of systematic industry has now more fully led it. The invention of Arkwright's water frame, a machine too heavy and complex to be easily worked for any length of time by human strength, necessitated the introduction of the factory system, and the use of a motor of greater force, which was first found in horse, and then in water power. Hargreaves had founded a mill in Mill Street, near Chapel Bar, Nottingham, and furnished it with his jennies, for which, however, the operative alone supplied the power to work. In near proximity to this, in Woolpack Lane, in the same town, Arkwright, and Smalley,

his Preston friend, established their first mill, the machines in which they operated by horses. This mode did not prove satisfactory, and their means becoming exhausted, the assistance of capitalists was secured, and by their aid the mill at Cromford, in Derbyshire, was founded, which substantially became the model of many others established by that enterprising inventor. It may interest the curious to name a few of the mills with the establishment of which Arkwright was connected. Besides those just mentioned, Arkwright built Masson Mill, near Cromford, a mill in Miller Street, Manchester, one at Adlington, near Chorley, and, we believe, several in Scotland. His firm subsequently, we understand, acquired Mellor Mill, Derbyshire, founded by Samuel Oldknow, so picturesquely situated on the Goyt, near Marple. The concentration of the spinning industry in mills which thus took place by this development of the factory system, was a very powerful factor in effecting the separation of the industry into the two branches of spinning and weaving, and the increased capacity of production liberated thousands of operatives for absorption into the weaving branch, in which at that time there was a great demand for workers. A rapid extension of the trade took place, manufacturers purchasing yarn from spinners and giving it out in the form of warp and weft to weavers in the country districts, who returned it in the form of cloth. Thus the separation of the industry into two parts was enforced by the process of growth. The men who thus "put out" yarns, as it was termed, for weaving, were called at first manufacturers, and subsequently hand-loom manufacturers, to distinguish them from the power-loom manufacturers, who afterwards became their formidable competitors, and finally drove them from the field. During the period from 1815 to 1830 there were in Lancashire and the adjoining portions of Yorkshire, Cheshire, and Derbyshire, between 240,000 and 260,000 hand-looms employed. After the latter date there was a rapid decline in the numbers, the improve-

ments effected in the power-loom enabling it to supplant them.

The course of this revolution in weaving seemed at one time to promise a perfect reunion between the two sections of the trade, as the spinners began to put down looms to consume their own production of yarn, whilst, on the other hand, the manufacturers, having acquired wealth, procured spinning plant to supply themselves with yarn. Thus the second series of mills that arose combined both branches of the industry. The power-loom, at its first introduction, and for forty years afterwards, was available only for the production of plain cloth, chiefly known as domestics, shirtings, and printing cloths, for which there was a steady and growing demand. With extending trade and the increasing capacity of the power-loom, the several districts in which manufacturing was carried on began to develope specialities in cotton goods that were hitherto unknown. Stockport, in the early days of the present century probably the greatest weaving centre, made domestics and printing cloths; Preston devoted its energies to long cloths, shirtings, and muslins for the home trade and for India; Blackburn chiefly made long cloths and printing cloths; and whilst Manchester and Radcliffe mainly engaged themselves with coloured goods, fustians, &c., Bury and Rochdale adhered to the woollen trade, making flannels, blankets, and goods of a like description. The remainder of the Lancashire towns had scarcely emerged from the character of villages, and the declining hand-loom trade was chiefly carried on within them. This tendency to recombine continued until about 1850, when the adoption by this country of a free-trade policy in commercial matters gave such an impetus to the trade, that from the last-mentioned date until 1860 an enormous extension of the industry took place. In East Lancashire weaving sheds arose on every hand, and correspondingly, to supply them and meet the expanding foreign demands for yarns, a large number of spinning mills were erected in Oldham and the

adjacent villages, which now rapidly began to assume the dignity of towns. Thus the tendency to divide received a new impetus. To build combined spinning and weaving mills required a large amount of capital not often found in one or two hands; but weaving sheds could be erected for a comparatively small sum. The joint stock system had not then been applied in the cotton trade; it was reserved for the two following decades to witness the application and development of this important principle in connection with it.

Since 1850 the forces tending to divide the trade have been continually in the ascendant, and it would now appear as if they had given a permanent character to its division. The widening of our commerce, and the demands made upon our manufacturers for an increasing variety of fabrics, in substance, quality, and style, almost preclude the possibility of combined spinning and weaving establishments meeting the requirements of the markets economically, whilst upon any other basis the severity of competition precludes business being carried on. Spinning mills must be furnished with machinery fitted to produce either coarse, medium, or fine counts of yarn: they cannot with advantage and economy alternate from one to the other of these descriptions; and weaving sheds attached to them are by that fact, to a certain extent, limited in their range of the market, and deprived of utilizing a certain amount of their capability to meet its wants. With very slight modifications of their plant they could, if free from a spinning mill, change from coarse to medium counts of yarn, or from medium to fine, and back again when circumstances rendered it desirable. But the weaving establishment attached to a spinning mill is compelled to consider the capability and requirements of the spinning section, and in certain conditions of the market may have to decline orders that its untrammelled neighbour can accept. In practical work this occurs oftener than might at first sight seem likely, and, in the course of years, appreciably adversely

affects the prosperity of the concern. The conclusion is, therefore, obvious and sound that the division of the cotton trade into the two important branches of spinning and manufacturing is assured and permanent. This being so, it is assumed that the requirements of students will best be met in the following treatise by recognising the fact, and assuming that the practice proposed to be elucidated is that which would be the best for, and the one adopted in, a weaving establishment not connected with a spinning mill.

CHAPTER II.

EARLY WEAVING AND THE DEVELOPMENT OF THE HAND-LOOM.

Weaving an ancient art; definitions.—Its origination in man's necessities.—Classic stories of its invention.—Modern research and geographical discovery show its wide prevalence.—Conjectural origin.—Ancient Egyptian weavers, their looms and materials.—Survival of the purely manual art.—Progress of invention.—Supposed looms of the fourth century, A.D.—Stimulations to further improvements; successive advances.—The shuttle in its incipient stages; its gradual development.—The lathe in its earliest and some succeeding forms.—An equipoise between the several parts of the loom; also between spinning and weaving.—The horizontal loom and its gradual improvement.—The Indian loom; the pacing motion.—The loom as Kay found it; its survival in Wales to the present time.—The Indian loom described; the Indian weaver humidifies his warp.—Loom of Sumatra and Java.—Of Japan.—Of Salomon Islands.—Of New Caledonia.—Of Ashango Land.—Kay's invention of the fly shuttle.—Disturbs the balance between spinning and weaving.—Robert Kay's invention of the drop shuttle-box.

WEAVING is an ancient art that has engaged the attention of both early and modern writers, as quite befits its importance. The former, however, have generally confined their notices to incidental references, that are more valuable from what they suggest regarding its condition and details, than from what they actually reveal. The latter have endeavoured to give an exposition of the art more or less full, and their works have mostly appeared within the second half of the last, and during the course of the present century. The remarkable growth of

literature relating to the weaving industry within this period arises from the fact that its greatest developments, and those which have called for scientific exposition, have taken place within its limits.

As might be expected, the art of weaving has been variously defined, and it will be interesting and instructive to the student to have the most important of these definitions brought under his notice. The great lexicographer, Dr. Johnson, with the care, correctness, and ability that usually distinguished his work, thus explains it:—

"Weaving is an art by which threads of any substance are crossed and interlaced, so as to be arranged into a permanently expanded form, and thus to be adapted for covering other bodies."

Consideration will shew that this definition will be difficult to improve upon, and in proof thereof it may be stated that James Yates, M.A., the learned author of the article "Tela," in Smith's "Dictionary of Greek and Roman Antiquities," adopts it in that article, and also in his later work on the same subject, "Textrinum Antiquorum." Unfortunately for the students of the textile arts, the latter work is a fragment—only one volume having been published—which treats of the raw materials, vegetable, animal, and mineral, employed in the industry. Dr. Ure in his "History of the Cotton Manufacture," with some little pedantry elaborates and refines upon Johnson's definition, though hardly to the edification of the ordinary reader, as will be obvious from the following:—

"Weaving is the art of making cloth by the rectangular decussation of flexible fibres, of which the longitudinal are called the warp, and the transverse the woof, or weft."

In the above definition Dr. Ure appears to have imitated Dr. Johnson's definition of lace, which is: "Anything reticulated or decussated at equal distances, with interstices between the intersections." John Murphy, author

of the standard and justly celebrated treatise on "The Art of Weaving," gives no specific definition, neither does Clinton C. Gilroy in his well-known work bearing the same title as the foregoing. The latter, it may be remarked in passing, is distinguished by a remarkable and realistic piece of satirical writing directed against the too common practice indulged in by many people, of alleging that nearly every modern invention connected with the textile industries had been anticipated by the ancients, and that therefore inventors of the present day were entitled to little credit, and consequently to no protection for their devices. This satire composes the introductory chapter to the work, and extends to seventy pages. It has often deceived people who have taken seriously the statements contained in it as veritable history; it is mentioned here in order that its true character may be pointed out. White, a Scotch author, whose work on "Weaving by Hand and Power" was published in 1846, contents himself with a very simple definition, which is as follows:—"Plain weaving consists in the interlacing together of two lines of threads at right angles to each other." Watson, another Scotch writer, whose essay appeared in 1866, gives a still more bald outline, defining weaving as "the making of cloth from yarn or threads." Only another example need be adduced, which shall be from a recent work on "Weaving and Designing" by Mr. T. R. Ashenhurst, late teacher of weaving in the Technical School, Bradford, Yorkshire, published in 1879:—

"Weaving is the art of combining threads, yarns, filaments, or stripes of different materials, so as to form a cloth. This combination may take a variety of forms, according as the intention is to produce plain or fancy material."

The present writer may be permitted to give a definition:—

Weaving is the art of arranging, at right angles to each other, two or more series of threads of any suitable

material, and binding them together by passing each thread under and over, and sometimes partially around one another in regular alternation, or in such other order as may be needed to produce the required effect, by which arrangement they assume and retain an expanded form, rendering the fabric adaptable to many uses.

The origin of weaving can only be conjectured ; it is lost in the mists of past ages. History says nothing of its beginning ; the earliest mention of the art showing it, comparatively speaking, in an advanced stage of development, and which, judging from its slow growth in subsequent times, could only have been attained through centuries of almost imperceptible progression. Whether it began in Assyria, Egypt, Persia, or India, cannot be gathered, because when first referred to by ancient writers it is inferentially clear from their statements that it was known in all those countries. In lieu of positive knowledge, therefore, we must fall back upon tradition, and when this slender staff fails to give support, we must retire upon the safer deductions of reason, and see if we can glean therefrom a shadowy reflection of the facts.

"Necessity," says an old adage, "is the mother of invention," and the art of weaving, like most other arts, owes its origin to the pressing needs of mankind. Of all animals man is the only one for whom it may be said nature has been at no trouble to provide clothing. It is true that in a very primitive state, and in the warmest latitudes, he runs naked, and feels no necessity for any addition to the scant provisions of nature. But immediately he steps over the boundaries of these districts the lowering temperature develops a desire for clothing. The conclusions of modern science concur with Biblical and other ancient writers, that in the primeval ages men killed the beasts of the field for food, and clothed themselves with their skins. These would differ considerably in suitability for this purpose, though experience would soon teach them to select the best. But the best clothing that

could be fabricated from these materials in the then state of knowledge of their treatment, would leave much to be desired in the way of comfort. Hence would result the development of man's inventive faculties. As observed above, however, of the outcome of this as applied to the art of making clothing, we have no positive information. The book of Job is one of the most ancient pieces of writing in the possession of modern times, and every child is acquainted with the beautiful simile it contains drawn from the textile art, in which the patriarch, desirous of expressing the rapidity with which time was passing, exclaims: "My days are swifter than a weaver's shuttle." Of course the shuttle referred to was not the shuttle of to-day, but notwithstanding this, the simile incidentally reveals that the progress attained in the writer's time in this art had been considerable. None of the sacred writers speak of the invention of the art. Wherever a reference to it is made, it is indicative of its being in an advanced stage of development.

The classic writers throw a little more light upon the origin of the art of weaving than do Biblical ones. Amongst the nations of antiquity are several on whose behalf claims have been put forward to the invention. Pliny informs us that "the Egyptians put a shuttle into the hands of Isis, to signify that she was the inventress of weaving." But though I am strongly disposed to think that weaving may have originated on the banks of the Nile, the fact that a shuttle was placed in the hands of this goddess may have indicated more that she was a patroness of those who pursued the art, than of any claim to the invention. Semiramis, the celebrated queen of Assyria, has also been brought forward as a claimant for this honour, but so far as can be ascertained, with no better evidence than that advanced in favour of the feminine deity of Egypt. The habit of deifying or semi-deifying their most celebrated rulers, prevalent amongst ancient nations, led to the attribution to them of the origin of

every useful art. This will sufficiently account for the existence of claimants to the invention of weaving amongst nearly all the peoples of the ancient world. This fact strongly indicates that all clue to the origin had even in those early times been lost.

Modern research has shown that the art of weaving was widely prevalent amongst the most celebrated nations of antiquity, and was by them carried to a high degree of perfection, probably as high indeed as manual skill was capable of reaching. The phases of civilization developed in ancient Egypt, Assyria, Phœnicia, Greece, and Rome have all passed away with the peoples who originated them, but their remains still exercise a great influence upon the civilization of modern times, especially on its artistic side, which is the most visible. It will be doing the latter no injustice, nor depriving them of any credit, if it be affirmed also that the origin of many of the most useful arts, amongst which weaving takes a foremost place, must be sought for in the same source, though the course of descent may not always appear on the surface.

Geographical discoveries during the past three or four centuries, amongst the other wonders that they have revealed, have shown that the art of weaving has long existed and been carried to the highest perfection amongst the nations of the far East, whose existence was practically unknown and undreamt of until after the discovery of the mariner's compass. The natives of India, China, Japan, Borneo, and the subjacent countries, were all found to be possessed of this useful art, and, with modifications, to have carried it to a high degree of advancement. In the most recent times the opening up of Africa ("the Dark Continent") has shown the art in a very primitive stage of development amongst its rudest tribes. Crossing the Atlantic to the new world, when the white man first landed upon its shores he found that the various tribes of the natives were experts in manual weaving. It has also since been discovered that it was a well-known art

amongst the ancient races of Mexico, peoples who were unknown even by tradition to those whom Europeans found occupying the country, and whose existence is only attested by the wonderful remains they have left behind them, which demonstrate their possession of a peculiar yet highly-developed civilization. Passing from the mainland of the American continent to the isles of the Pacific, Captain Cook and his successors, in the explorations of these seas, found the natives of the various groups of islands that they discovered quite adepts in the production of simple woven fabrics from the fibrous materials indigenous to their respective countries. And thus it is all round the globe—wherever explorers have gone, they have found amongst every race and nation this useful art in either a primitive, middle, or advanced stage of growth.

It will be seen from the preceding that neither historical research, antiquarian investigation, nor geographical explorations have revealed the origin of the art, the date of its invention, or the name of the first weaver. It takes little intellectual effort to resolve into myths the claims brought to light by the former in favour of certain shadowy individuals of the past. In lieu then of positive knowledge a guess may be hazarded. How came mankind to conceive the idea of weaving? The answer is clear. It must have been to obviate some inconvenience, or secure some advantage. What could this have been? Perhaps a little consideration may reveal the possible, if not the probable, genesis of the idea. The apron of fig-leaves may be dismissed, as also may the thought of any other article of attire. For dress purposes the skins of animals, both wild and domesticated, for many ages would amply suffice for the requirements of the human family in this respect, so that no stimulating inconvenience would be encountered here. Skins would also serve for the construction of tents when mankind began to think it desirable to seek shelter

from the heat or inclemency of the weather. Up to that time the natural grasses of the earth had no doubt formed a satisfactory couch on which man could lie down to repose in the heat of the day, or after its labours were over. But when he resorted to tents, which may be supposed to have been made of skins, the grateful floor covering which nature had provided would soon be worn away. The bare earth would not prove agreeable, and it would soon be discovered that it would often be easier to provide a substitute for nature's carpet than to pull down the tent and remove to another plot. The most convenient ones would be resorted to, and thus, in some instances, skins, leaves, grasses, or reeds would be procured as useful substitutes for the growing herbage. These were most probably the first artificial carpets, and it is in connection with the development of this emblem of modern civilization, in the opinion of the writer, that weaving would originate.

Conceding, and indeed affirming, that the balance of probabilities points to Egypt as the country in which weaving was first invented, it may be pointed out that in all past times, as at present, the population of that country has mainly been concentrated upon the lands bordering upon the great river Nile, the old and celebrated stream which a few years ago engaged so much of the attention of Englishmen, and where events of great importance transpired. From the days of the Pharaohs down to the present time the swamps of the Nile have been noted for the abundance of vegetation they produce, and which has been applied to various uses: witness, for instance, the ark of bulrushes in which, in the days of the sojourn of the Israelites in Egypt, it is recorded the infant Moses was placed. What more natural than that the flags from the river should be used for floor coverings? These would be strewn about the floors of the tents and dwellings of the people, as rushes were in this country only two or three centuries ago. It would not be long before Egyptian

mistresses and Ethiopian maidens would devise means of utilizing them for decorative purposes; especially as when by so doing their durability would be enhanced, and the comfort obtained from their use increased. Indiscriminately thrown upon the floor they would be trampled up, to avoid which the first plan adopted would probably be to place them longitudinally side by side. In this we get the first step in the art of weaving: a parallel arrangement of reeds or flags. The next, the introduction of transverse ones, would speedily follow, as an ornamental effect would be obtained by laying others across those first placed in parallel order. The second step is thus arrived at: longitudinally and transversely arranged flags; but still no weaving has taken place. As now supposed to be laid, they would be liable to derangement every time a person moved across the floor, which would destroy the ornamental effect. To prevent this it may be assumed that various expedients would be resorted to before it dawned upon anyone's mind that the transverse flags should be made to pass alternately under and over those laid in a longitudinal direction in order to secure a comparatively permanent arrangement to the mass, and such as had never been obtained before. Increased utility combined with a beautiful effect would be the outcome of this disposition of the materials, and it could not fail to strike observers very forcibly. Such would possibly, even probably, be the first woven fabric, and its conspicuous advantages would speedily secure extensive imitation and general adoption. This conjecture, it may be observed, is based on a substratum of fact.

The first webs fabricated in the manner thus supposed would only be of the size that could be made from single flags; when large ones were wanted the longest flags would be selected to produce them. Still, the desire for some of larger dimensions which would arise would remain ungratified until the difficulty in the way was overcome by the discovery of some means of attaching one

length to another, which to a certain extent would solve the problem. Before the last-mentioned stage of development the operation would be purely manual, and would need only one individual to perform it. But the increase in dimensions would necessitate the introduction of implements, crude and simple at first, but containing the germs of the wonderfully perfect and complex mechanism of the loom of modern times. The first would most likely be a piece of wood that the worker would lay across his longitudinal reeds to maintain them in position, whilst he lifted and depressed them alternately in putting in the woof, or those that had to occupy a transverse position, which he would push up to the one previously inserted. Here is the beginning of what has now become the cloth beam. His next advance would probably be to place a second beam of similar dimensions and character at the opposite extremity of his loose warp, which would thus be extended and held at both extremities. This would further facilitate his work, as, instead of having to handle all his warp-threads, as they may be called, he would only have to contend with the woof he was inserting transversely, which he would rapidly pass under and over the longitudinal flags thus held down at each extremity.

Amongst the picture writings of Egypt's ruined palaces and temples representations of the ancient methods of pursuing the art of weaving might naturally be expected to be found, and this anticipation has been justified by the discoveries that have been made. Sir Gardner Wilkinson, in his "Manners and Customs of the Ancient Egyptians," has reproduced three drawings from pictures on the walls of Thebes, showing several weavers at work, and illustrating three forms of the loom; or, more correctly speaking, a purely manual process, a rudimentary vertical loom, and a more advanced form of the latter loom. These illustrations are from the tombs of Beni Hassan, which have been fixed by the best authorities to belong to a period 3,000 years before the present era. These representations

were found by Menutoli, and need little description. The framework, if such it can be called, of the first, fig. 1, consists of two transverse bars, which are attached to the pegs secured in the ground. Between these bars the warp is extended, and the weaver sits upon that part of the web already finished, and interweaves his materials without the assistance of anything in the nature of a shuttle. In the original the fabric is shown to be a small, delicately chequered pattern of yellow and green, and from the materials spread around it is inferred that the yarn was dyed in the wool before it was placed in the hands of the

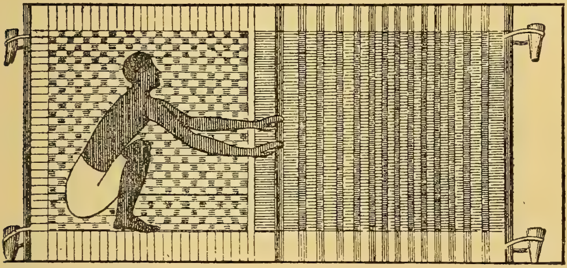


FIG. 1.—ANCIENT EGYPTIAN WEAVER.

weaver. This illustration, if not intended to represent the method of mat-weaving from broad-leaved plants, is evidently very closely derived therefrom, and is so perfectly manual as hardly to show more than the slightest advance upon the stage depicted in the preceding conjecture. The other illustrations exhibit a further development of the loom, and will come under notice presently. The ideal presentation, given in the preceding observations, supported as it is by this Egyptian picture, is offered to the consideration of the reader as affording an approximately correct notion of the genesis of the art of weaving: the earliest stage of an industry that has for untold centuries

contributed in a very high degree to the comfort and welfare of mankind.

In fig. 1 we have got the loom in its most primitive form. It is a beautiful illustration, and is interesting because of the support it affords to the most reasonable conjectures that have been formed by students of the natural evolution of the loom from the simple beginnings endeavoured to be pourtrayed here. The weaver sits or crouches upon the part of the web already woven, and as no appliances for shedding are visible, no other inference can be drawn but that the fabric is formed by passing by hand the transverse material alternately under and over the longitudinal threads forming the warp. From the manner in which this material is represented as extending beyond the edges of the warp, it would seem that there was no selvage to fabrics constructed by this method, which would again support the conjecture that the materials were simply flags from the shallows of the river. But if not the same, it requires no stretch of the imagination to conclude that it has been drawn from that source. It may be remarked in passing that the pattern is exactly the one that would result from the interweaving of the leaves of this plant. It is remarkable that flag leaves are still used in Egypt and other lands of Northern Africa for making fabrics of the kind described, which are used for packing the coarser sorts of figs and dates for export to England and other European countries, where they may be seen in our principal markets.

The purely manual form of weaving survives to this day in the art of basket-making, in which it has been carried to a high degree of perfection, especially by the Japanese, fine and beautiful specimens of whose skill may frequently be found in this country. In another, and its very simplest form, it may also be discovered in working men's households, where the careful housewife, in the process of darning hosiery, first extends a number of threads lengthwise of the hole in the stocking, attaching

them to the body of the fabric. These form her diminutive warp. She next proceeds to insert the weft or transverse threads, passing them alternately under and over those of the warp which is extended between her fingers. The needle in this operation performs the function of the shuttle, to the ancient form of which it bears a strong resemblance. It is to be feared that this is a domestic accomplishment of diminishing prevalence. On the Continent, and especially in Germany, young girls are taught the art of darning at school, and become so expert that

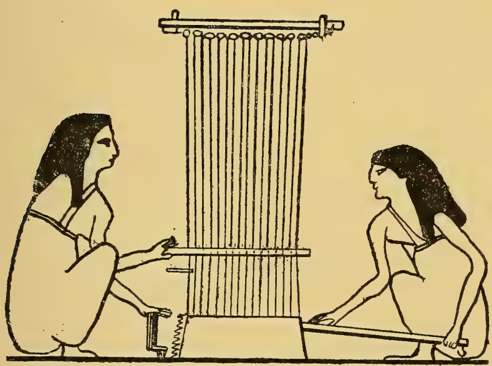


FIG. 2.—VERTICAL EGYPTIAN LOOM WITH TWO WEAVERS.

they often repair the finest woven fabrics with such skill that the place can hardly be discovered. In most of the textile industries, and particularly in cases where the fabric is valuable, repairs of damages are also effected in this manner.

The reason of the next move in advance being made will be obvious. As will be observed from fig. 1, the weaver sits or crouches upon the portion of the fabric already made, and works towards the end of the extended warp in front of him. This constrained attitude must have been exceedingly irksome, and it need not be surprising that

the next step should be one that would raise the warp from the ground. Accordingly we find in the construction of the loom as shown in fig. 2, which is derived from the same source as fig. 1, a resort to the vertical arrangement of the warp. Hence comes the high loom retained to this day in tapestry weaving. It really involved little change beyond raising the beam to which the warp is fastened, as seen in fig. 1, and suspending it probably from the roof of the dwelling. This illustration shows one or two points that call for remark. There are two operators who evidently pass the weft or the filling through the warp to one another, the one on the left commencing the operation; the second receiving it, bending and returning it. It will be observed that the filling projects on the left-hand side beyond the edge of the cloth, which indicates that whatever may be the material, in its length it did not suffice to pass more than twice across the warp, thus making one raw edge and one self edge. This is an advance upon the results shown as obtained in fig. 1, where both edges are raw. It may be assumed that two weavers work together as in this instance for the sake of the facility and increased production obtained. In other cases, as in fig. 3, also that of a vertical loom and probably in contemporaneous use with the preceding one, there is only one weaver, who is shown sitting to work. These three figures, all from the tombs of Beni Hassan, sufficiently illustrate the art of weaving as practised amongst the ancient Egyptians. Whether much progress was made by them from this point is not known. If their fine linens such as are found to-day wrapping the mummies were made upon and by these crude means, they afford the most convincing testimony of their great skill.

It is probable, however, that the loom in these forms existed a long time in Egypt, as no evidence exists that we are aware of showing any important advance upon them in this country. In these forms they were probably carried first to Greece, and thence to Italy, as it is in

those countries we next find the earliest evidence regarding the loom. Montfaucon, a French monk and a voluminous writer of the early part of last century, in his great work, " L'Antiquité Expliqueé," says, " It seems, from figures which remain to us of the fourth or fifth century, that they worked at their art with much simplicity. We have some women who are spinning, with others who are weaving; those who make the linen or the cloth of wool are standing. In the ancient Virgil,

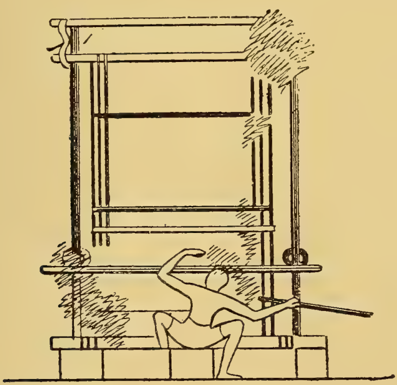


FIG. 3.—SINGLE EGYPTIAN WEAVER AT VERTICAL LOOM.

in the Vatican, which is believed to be of the fourth century, and which formerly belonged to our Monastery of St. Denis, in France, which I have shown in my journal on Italy, we see a woman who works at a piece of linen or stuff, and this woman, who is standing, instead of a shuttle makes use of a long staff (fig. 4). I leave those expert in this art to reason on this manner of working in linen or in cloth of wool." This is simply the vertical loom of the ancient Egyptians that we have already seen. It appears to have been first transferred to Greece, and afterwards to Rome without having undergone much

change in its migrations. Very likely the rod was used as both shuttle and batten or lay, but owing to imperfect delineation it has been shown without the hook at the end which was used in drawing the weft through the warp. The old Benedictine Montfaucon with all his wondrous store of knowledge quite failed to observe that the Roman

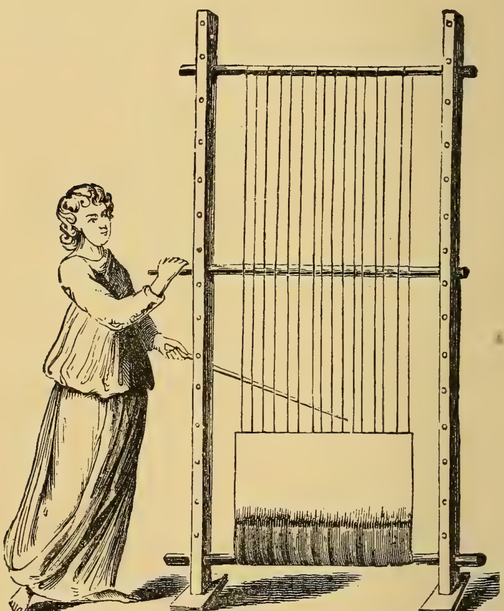


FIG. 4.—GRECIAN VERTICAL LOOM.

and Egyptian looms were practically identical. In using this illustration Dr. Ure, in his "Cotton Manufacture of Great Britain," erroneously terms it a warping frame. But there were disadvantages in the vertical arrangement of the warp that undoubtedly would in some instances cause a reversion to the horizontal position whilst an endeavour

would be made to obviate its defects. This would be accomplished by raising the warp from the position shown in fig. 1 to the height of about three feet at which the weaver could work in a sitting position. To secure this the short pegs would be lengthened until they might fairly be called posts. The strain of the warp, however, in this position, would have a tendency to pull them together, which would be obviated by placing parallel bars between them, first one on each side, then two, and next transverse bars between the beams at each extremity of the warp. With the change indicated a new difficulty would arise. With a fabric of ordinary width, and working from the front as before, with the warp in this position, the weaver could not, if he endeavoured to insert his weft from the side, reach across. Here, probably, may be discovered the origin of two weavers working at one loom, a plan which, under modified forms, survived, even in this country and upon the continent of Europe, until far past the middle of the last century, and which may continue even to this day in secluded districts of the unprogressive countries of the continent and the stationary lands of Asia. This, however, would be an inconvenient arrangement. Many a time two weavers would not be available for one loom, and the other would of necessity be rendered idle until the time his fellow should arrive, when some one more ingenious than the rest would endeavour to overcome his constrained idleness by the invention of a mechanical substitute for his or her absent colleague. What more natural than that he should lengthen his arm, or power of reaching across the warp, by means of a stick? It would have been amusing, even in those days, to see the look of astonishment that would rise on the face of an idle weaver when he returned to work to find that his more industrious and ingenious colleague had been able to dispense with his services, and had finished his task; in fact, it would foreshadow many dramatic pictures of a like kind that occurred in subsequent ages. The stick thus

supposed to have been introduced, however, had no hand at its extremity, whereby to hold the thread it had to carry across the warp. The displayed fingers of the hand would speedily suggest a means of overcoming this difficulty by cutting a cleft in the end, which would meet the requirement, whilst subsequently the bent finger would suggest a further improvement in the addition of the hook, which we have already seen was used by the Egyptians. These advances, slight though they may appear, would constitute substantial improvements. This stick, or rod, specially prepared, whilst possessing the functions of the shuttle, was also used as the batten or lay to press the inserted threads successively to the fell of the cloth or edge of the portion previously woven. These improvements, of course, would not be effected in a day: most probably a considerable number of years passed away before they were all accomplished.

It will be obvious that the process of inserting the weft, pushing the rod carrying it alternately under and over the warp threads, exactly as a woman does her needle in the process of darning, was an exceedingly tedious one; and as long as it was followed the labour of the most industrious worker could not be very productive. The want, therefore, most pressingly felt, would be of a more expeditious way of inserting the weft. A brief study of the movements would show that each warp thread was alternately elevated and depressed when the warp was horizontal, and drawn towards or pushed away in its vertical arrangement to allow the weft thread to pass under and over in proper sequence, and that the adjoining thread was depressed when the first was elevated, and elevated when the first was depressed. It would thus become clear that an arrangement by which every alternate thread at one time could first be raised and then be depressed would yield what was wanted, and greatly facilitate the work. Here comes into view the requirement for, and the initial form of, shedding mechanism. How, and by what means, would

it probably be performed? It could only be by some means analogous to a leaf of heddles. Most likely the first attempts at shedding would be by the construction of a leaf of this kind, one of which, in the first instance, would suffice. By its means the threads could be lifted easily, so as to allow of the insertion of the first thread of weft, but more difficulty would be met with in depressing these threads below the level of the unmounted series in order to form a second shed for the next pick of weft. It is just possible that this difficulty may have been the cause of the invention of the vertical loom, in which the heald leaf could be pulled with ease in a horizontal direction on both sides of the warp, whilst the weft could be inserted with equal, if not greater, facility. In the method of working with one series of threads thus mounted, it would be found that they alone would yield to the strain, and bear the wear and tear of the reciprocal action of the shedding process, whilst the unmounted series would show an undesirable degree of slackness. But why not obviate the objection and, at the same time, increase the facility of working by mounting the second series of threads in a separate leaf of heddles, and pulling each leaf an equal distance in opposite directions, by which action the strain would be equalized upon both parts of the warp, and a shed be formed in half the time required with the single leaf? This, when thought of, would be speedily done, and would be found a considerable improvement in both the horizontal and vertical loom, though its advantages would be most strongly manifest in the former. This is what appears to have been done subsequently in Greece or Rome, as is shown in our second illustration from Montfaucon, if we may venture to try to interpret the crude drawings which he transferred to his pages from those of John Justin Ciampini, an Italian writer who died in 1698. Continuing from our last extract Montfaucon says: "Another manuscript of the King's Library, which is a commentary upon the Book of Job, shows us a

weaver who works at a stuff (fig. 5). The latter is also working standing. Although this manuscript is of the

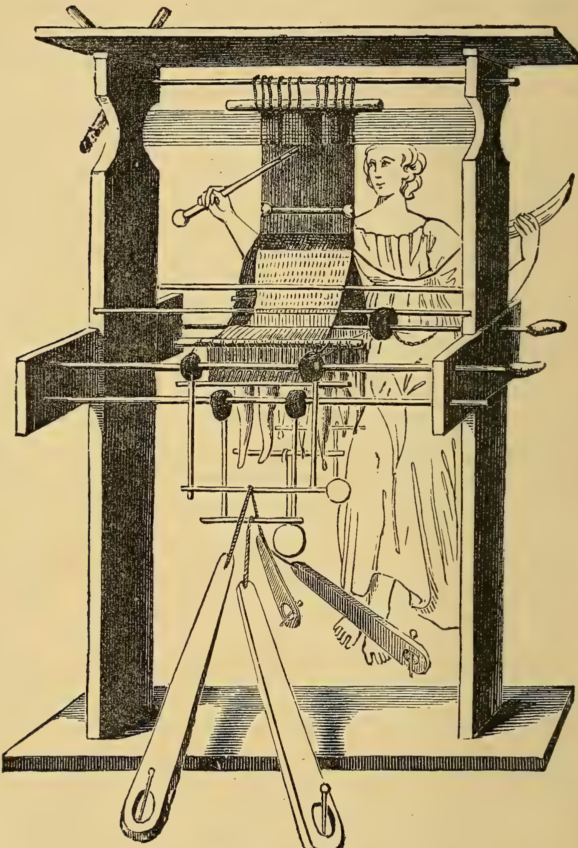


FIG. 5.—GREEK DOUBLE LOOM.

tenth century, the figures in it are drawn from MSS. more ancient: for, as it said in an ancient Commentary,

the oldest specimens of Job had these images depicted, which had been transmitted to the subsequent copies." Such are Montfaucon's observations upon the illustrations in his work of these two looms. Our figure is taken from the pages of Dr. Ure's "Cotton Manufacture," and whilst, generally speaking, it is a good one it has one or two defects. The first is that the figure of the weaver in Montfaucon's work is shown with the left foot upon the treadle just as if about to commence shedding the warp. This brings up the operation much more clearly than as given in this drawing. In the second case, the objects shown as dark balls are really grooved pulleys over which cords pass which are attached to the horizontal heddles. Thus the loom, which appears to be a double one at which two weavers could work at the same time, had its warps shedded by a treadling process assisted by balance or compensation weights that when the weaver removed her foot from the treadle carried the warp back to its proper position. This of course shows a great advance upon our previous illustrations as it brings the feet into action as well as the hands. It must have greatly increased the weaver's capacity of production.

The increasing facility of production arising from the successive improvements here conjecturally outlined would beget a demand for larger fabrics in both lengths and widths than had hitherto been made, or than could be produced in the then existing loom without further modification. Contemporaneous discoveries of, and improvements in, the art of preparing textile fibres, would enable the weaver, when he had supplied himself with the necessary modifications in his loom, to gratify this demand.

The development of the loom frame has already been traced up to a point where it may be regarded as being as large as the requirements of the time and conveniences might be supposed to need it. The domestic establishments of the ancients were not particularly noted for being

very spacious, and therefore an enlargement of the frame of the loom, or its extension by any additional projection, would be quite out of the question. One of the bars to which the warp was affixed would therefore be converted into a roller beam and the extra length of warp be wound upon it. This was a simple expedient, but it will be clear that it practically enlarges the narrow limits to the length of a fabric that had existed up to this time very largely indeed. If the warp was thus wound upon a roller at one end of the loom, why should not the woven fabric be wound upon one at the other side, and thus remove another inconvenience? This would be a necessity to get it out of the way of the weaver. Here, then, we have got the warp beam and the cloth beam. In countries where the operation of weaving was carried on out of doors, such as in India, these inventions only came into use at a much later date than in the countries bordering the Mediterranean, to which our remarks apply, and to which all that is known of the early history of weaving specially pertains. In India the weaver planted his simple loom under the shade of a tree (fig. 9), and extended his warp into the distance as far as necessity required. The invention of these beams restored the weaver to his primitive position, that which ultimately became and is now distinguished as the front of the loom. There was, however, as yet, no pacing motion to the warp beam, nor taking-up motion to the cloth beam; these were additions of a much later date. It is probable that the weaver, when he had filled his warp too near the point at which his healds were hung, would go to the back of his loom, roll off the warp, return to the front, and roll the length of woven cloth upon the beam intended for its reception. It will be clear that this arrangement would be inconvenient, and entail much care and trouble before a proper tension could each time again be adjusted. But such as it was, it no doubt endured for a long period before it was further improved. The subsequent illustration (fig. 10) shows both warp and cloth beam and a rude

tension arrangement or pacing motion. It is also shown to be under cover.

Hitherto it will have been observed that no mention has been made of the lathe and the reed. The necessity for the latter had not come to be recognized, and the hooked rod by means of which the weft was inserted combined the functions of both the modern shuttle and the lathe. At this point in the development of the loom the time of separation was approaching. The very early date at which the loom had attained the degree of progress upon which the present remarks are based will be apparent when it is pointed out that it must have been long anterior to the time in which was woven the cloth that modern explorers have discovered swathing Egyptian mummies. Fabrics made by the insertion of short lengths of weft threads would have one, if not both of their edges loose, and consequently liable to ravel off, unless the projecting portions were turned into the next shed, of which, in any of the ancient cloths that have been preserved, there appears no evidence. Neither in any of the mummy cloths, so far as we are aware, are loose edges found. The safe inference from this is, that either the hieroglyphs represent a state of the art existing long anterior to the time when the mummy cloths were woven, or otherwise the weaving of matting from the flags of the river, which might exist alongside of the more advanced form of the art represented by the capability to weave the fine linens with which modern times have been made familiar. The representations of the textile arts amongst the Egyptian hieroglyphs are so few in number and so imperfect in detail, that the latter conjecture is most probably the correct one. The forms portrayed are the simplest ones, such as would invite selection for representation, whilst the more perfect, and consequently the more complex ones, would act rather as deterrents.

It must be remembered that whilst the loom was undergoing the development just sketched, the art of spinning

threads from the different fibres was improving in like manner. The possession of a continuous thread would be a great boon to the weaver, not only in the preparation of the warp, but also for use as weft. The rod, which it has been seen, was in use for inserting the weft, would not be adapted for using a continuous thread, and hence the necessity for its modification. It became desirable that the weft carrier should go completely through one open shed and return by the next, continuously repeating its traverse until its cargo of yarn was used. One conspicuous improvement resulting from this method would be the formation of neat, strong, and firm edges that would not ravel off, as by the older plan. These have become in modern times known as selvages, properly self-edges. The passage through each shed of a long rod containing yarn would be found to be a great inconvenience, and the first effort to remedy this would be by shortening it. This would obviate much of the difficulty and accelerate the operation, but would still leave abundant room for further improvement. The load of yarn this germ of the shuttle carried would considerably impede its being passed through the shed, owing to its coming into contact with the threads of the warp, a fact which it would not take long to discover. The provision of a remedy for this would not be easy, and a long time would doubtlessly elapse before it was accomplished. In this rod containing weft yarn will be discovered the germ of the shuttle pirn or cop. The previous use of the long rod for inserting short lengths of weft yarn as picks would have taught these ancient weavers that a smooth piece of wood could with facility be passed between the threads of the warp, but how to get the yarn inside a piece of wood, or enclose it in a sheath of that material, would be the difficulty. It has been assumed all along that the development of the art of weaving, as hitherto traced, occurred in Egypt and the neighbouring countries, though principally in the first-named. An observant

weaver would not therefore have to travel far in order to discover suggestive material for the solution of his difficulty. The art of navigation would have grown sufficiently at the period supposed to be under consideration to have reached to the construction of a rude form of boat for use upon the waters of their famous river. It may safely be assumed also that Egyptian children in the early age would love the flowing waters of the Nile, and delight to play upon its banks, much as English children of to-day love the seashore, and take pleasure in freighting and launching upon the waves their toy-ships. What more likely than that the toy-boat of an Egyptian child first suggested the idea of a shuttle to the swarthy weavers of the Nile valley? At the present day there is a striking likeness, both in form and function, between a boat and a shuttle, and it is well known that there now exists on many of our inland canals a form of boat called a shuttle. The idea once seized upon, the construction would speedily be modified to suit it for its special function. This invention or adaptation would give a wonderful impetus to the weaver's art, because of the manner in which it would expedite production; as, instead of being slowly and with difficulty put through the warp-shed, it could then be rapidly passed from hand to hand. The Greek weaver shown in fig. 5, *ante*, is an illustration of the later Greek loom in which this stage of advancement is shown, the woman represented having the shuttle in one hand and the sword or batten in the other. It is quite possible, however, that in assigning the invention of the shuttle to this early date, and to Egypt at all, the period may have been anticipated, and the honour awarded to the wrong country altogether. Assyriologists of late years have begun to put forward strong claims on the part of Assyria for the honour of precedence over Egypt in the arts of civilization.

This change in the form of the shuttle would induce another important advance. It has been shown that up

to that point the function of the batten, lathe, or slay, and the shuttle, had been combined, and that the long rod by which the weft was inserted was used to beat it home. The new form of the shuttle, however, was unsuitable for this purpose, and therefore a rod specially adapted for it was constructed and used instead. The illustration from Montfaucon shows this rod. In some cases a comb, rudely made in the form of the human hand, was used to bring the weft into its position at the fell, after which the spatha, as the rod just mentioned was called, was introduced into the shed to give it the final blow and drive it home. The form of the comb indicates its origin, and points to the early use of the human hand for the same purpose, which has been shown previously. In the comb and the spatha, if the human hand be omitted from consideration, is discoverable the origin of the modern lathe and reed, the functions and actions of which have been conjoined, and have had another added to them, that of preserving the parallelism and equi-distance of the threads of the warp.

Assuming that the development of the loom took place much on the lines here laid down, it will be seen that a point has been arrived at in which there is a sort of rough balance or equality of facility in the performance of the different actions in the process of weaving. The shedding would be done by hand; the shuttle was cast through the warp by the same means; and the weft was driven home by the same instrumentality with the tools just pointed out. The same comparative equipoise existed between the production of yarn and its consumption. It is in positions of this kind that pauses are apt to occur in the rate of improvement. No difficulty conspicuously obstructs the progress of work, and hence ordinary intellects are not stimulated into a manifestation of their skill. The loom might easily continue in this state for ages before any further important advance was made, which would probably result more from the inspiration of a bright mecha-

nical genius, than from the pressure of facts upon ordinary intelligences.

The next step in advance would most likely take place in the horizontal loom, and would consist in an improvement of the shedding appliances, enabling the weaver to operate this part with his feet, instead of hands, as before. This was probably what is still to be seen in the hand-loom of the Hindoo weaver of the present day, merely cords pendant from leaves of heddles with loops at the end, in which the operator inserts his great toes, alternately drawing down one leaf and then the other, whilst the corresponding one rises by which the shed is formed. The facility gained by this improvement would speedily lead to the conviction that the use of the comb and spatha was a slow and cumbrous process of getting the weft into its position in the woven fabric after its insertion by the shuttle. It will easily be seen that an enlargement of the comb, which might be gradual, to the width of the cloth would obviate much loss of time, and expedite the work; whilst the necessity of preventing the entanglement of the warp-threads, and the preservation of their parallel order, would lead to the construction of finer and finer combs, until strips of reed were combined in one frame large enough to reach across the cloth. The use of the enlarged comb would be cumbrous, and its repeated insertion into the warp-threads tedious and slow, until it was found that by pushing it back upon the warp the same purpose would be served, whilst weaving was greatly expedited. The strengthening of the comb by the increase of its weight and length would enable the weaver to drive home or lay the weft in its final position by its means, and thus dispense with the use of the spatha. This would eliminate one operation altogether, and to that extent simplify the process. At first the finest or lightest fabrics would only be dealt with in this manner, but the increased facility of production obtained from this method would soon suggest the strengthening of the reed-frame to fit it for use in the

heavier cloths. From this would speedily follow another improvement. The weight of the lay in this form would impede the shedding operations, an impediment to progress that would, in its turn, suggest the suspension of the lay from cords. To make the lay depend from two vertical bars attached to an axle on which it could oscillate easily, was one of the most important advances that had hitherto been made in the construction of the loom. It would probably take some time before it was perfected in its minor details, but these would naturally be added as their want became manifest. This arrangement, shown in fig. 6, would again greatly facilitate production, and in turn would lead to the introduction of the bore-staff for drawing down the warp from the front to preclude the necessity of the weaver's frequent journeys to the back of the loom to unwind it. Here again would be developed another difficulty, which would require further ingenuity to overcome. The draught of the warp from the front would too often leave it slack and unfit for shedding. The frequent interruption of work arising from this arrangement appears to have led, though at what date is not known, to the introduction of a plan to secure a uniform delivery of warp from the beam equal to the requirement of the weaver. This was the pacing motion. The earliest form of this arrangement was the old weight-rope, yet so extensively in use even upon the modern power-loom. This is a rope which passes once, or oftener, round the collar of the beam, and having a weight at one end and a counterweight at the other, or otherwise having the latter attached to a flat spring or to the loom frame. Various modifications of this arrangement took place before it attained the comparative perfection of the present state. In a French work, "Spectacle de la Nature," published in the first half of the last century, and translated and published in English in 1748, a drawing is given of a loom having the pace-weight, which is shown in fig. 7. The drawing is not sufficiently clear to show whether the rope

passes more than once around the collar of the beam, but it is clear enough to show that the action is automatic. A similar appliance is shown upon a velvet-loom, which is also portrayed in the same work.

The development of the loom has now been traced through its various stages up to the point at which it

FIG. 6.—FLEMISH LOOM ABOUT 1560.

remained until the new epoch of invention dawned upon the world. This has been done in order to show that, simple as its primitive form may appear to weavers in these days, there was really much more inventive skill and ingenuity required and expended in its invention and construction than appear on the surface. The sketch,

though mostly hypothetical, is not without historic support, as the brief references to the processes of weaving, and the implements used in the industry, that have been given from ancient writers, conclusively show. It will

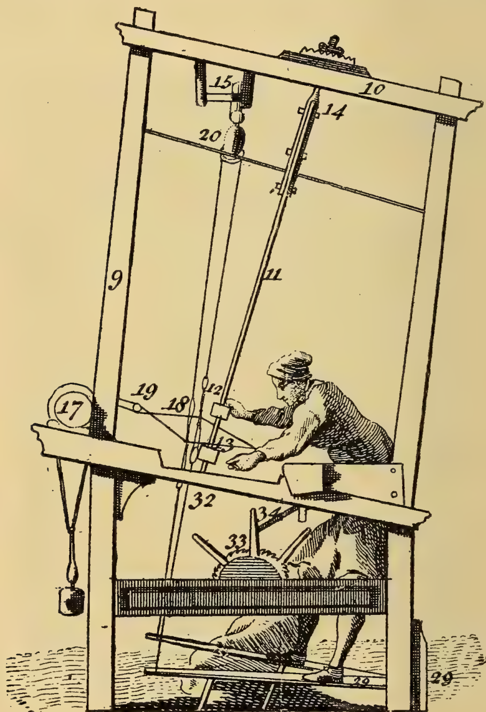


FIG. 7.—FRENCH LOOM, SIDE VIEW; ABOUT 1740.

be useful, therefore, to summarize the progress made, which can probably best be done by portraying the loom as it existed in the sixteenth and seventeenth centuries, and at the early part of the eighteenth, previous to

the invention of Kay's important improvements. Our illustrations are drawn from various sources. The first, fig. 6, is a simple loom, and the figure is taken from Schopfer's "Panoplia," published at Frankfort-on-the-Main in 1568. It needs no detailed description. The next two illustrations, figs. 7 and 8, represent a more advanced loom. They are taken from the French work just mentioned. They represent a side and front view

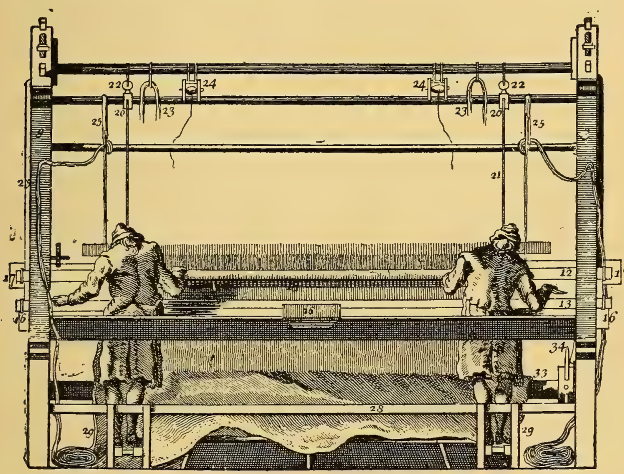


FIG. 8.—FRENCH LOOM; FRONT VIEW.

of a wide loom, which requires two weavers to work it. The frame consists of inclined posts, 9, and cross-pieces, 10. The batten, or lathe, depends from the top cross-bars, where it is carried upon a serrated bearing, by which it can be adjusted within a given range forward or backward, according to the requirements of the weaver, or of the fabric on which he is engaged. The lathe, it will be observed, is composed of its two uprights, 11, carrying its

two blocks, 12, 13, for the reception of the reed, the lower one not being furnished with the projection now called the shuttle-race, whilst the top one forms the cap, as in the power-loom of to-day. By means of the cross-piece, 14, the height of the lathe can be adjusted as required. The two leaves of heddles, 18, are suspended on cords, which pass over small pulleys depending from a piece of wood called "the gallows," 15. The breast-beam, 16, is a large block of wood with an aperture in it, through which the cloth passes to the beam or roller, 33, beneath the loom. The warp-beam, 17, it will be observed, has no spike, but rests in its bearing upon its collar. The great amount of friction surface thus obtained dispenses with the necessity of heavily weighting the beam for pacing purposes, this being accomplished by the small weight sliding upon the rope in a manner remarkable in this day of multifarious warp delivery arrangements. In the treading motion it will be seen that the treadles, 29, have their fulcrum at the front of the loom, instead of at the back, as generally obtained in a later form of the hand-loom. The weaver throws the shuttle from hand to hand. The cloth was templed by the old hand temple, 31, composed of two flat bars of wood, having pins at their extremity to enter the selvages. This temple could be shortened or extended, according to requirement. It will be admitted that the loom, as here shown, is a very simple thing indeed, and that it should have taken thousands of years to arrive at this stage of its development implies the existence of a remarkably low degree of the inventive faculty and of mechanical skill amongst the peoples of the various nations to whose comfort the art of weaving had ministered.

It is a remarkable fact, however, and one which forcibly illustrates the strength of the conservative sentiments of mankind, that in this age of mechanical invention, when the loom has been brought to a point of perfection beyond which it is difficult to conceive of its being carried much further, it should yet be found, as here pourtrayed, even

in this country. Five or six years ago the writer, whilst on a visit to South Wales, went to see the picturesque ruins of Caerphili Castle, in Glamorganshire. Leaned against an outer fortification he found a small woollen mill, and, curious to see how the processes of manufacture were carried on there, went inside, and was greatly astonished to find several weavers at work on such primitive looms as here depicted, even to throwing the shuttle from hand to hand. A pleasant chat with these old-time weavers, probably lineal descendants of the Flemish weavers planted in South Wales by Edward III., elicited the information that there were still a considerable number of such looms working in the locality around, and in Newtown and districts in Montgomeryshire.

Perhaps it may be desirable, for the sake of technical students, at this point to give a few illustrations of the loom as it is found to-day amongst Eastern peoples and semi-civilized races, where the art of weaving yet exists in a very primitive form. Of Eastern peoples those of India claim the first notice, chiefly from the early development and the high degree of excellence the art of weaving attained amongst them, the latter of which was due more to the exquisite manual skill of the workers than to the quality of their appliances. So far as can be discovered the Indian loom has undergone very little improvement in the course of many centuries. As it now exists it is probably as ancient as the single-thread spinning wheel of the same country. The illustrations (figs. 9 and 10) will show that it is constructed upon the same principles, and embodies nearly the same parts, as those of the European hand-loom, the development of which has just been attempted to be traced. The slight frame consists of two or four upright posts consisting of bamboo canes, with similar canes extending along the sides at the top, whilst, from a cross-bar between the two sides, the healds are suspended. A similar bar at the back in some instances forms the warp beam, whilst in others the warp is extended its whole

length. The cloth beam has in it a groove, into which a strip of bamboo, passed through the looped end of the warp,

FIG. 9.—INDIAN OUT-DOOR LOOM.

is fixed, and thus secured in the groove, precisely as in the English hand-loom, and also as in its successor, the cloth beam of the modern power-loom. The cloth is wound

upon the beam by means of a winch or ratchet-wheel, as in the loom just mentioned. The healds are treadled from beneath by the weaver inserting his great toe in

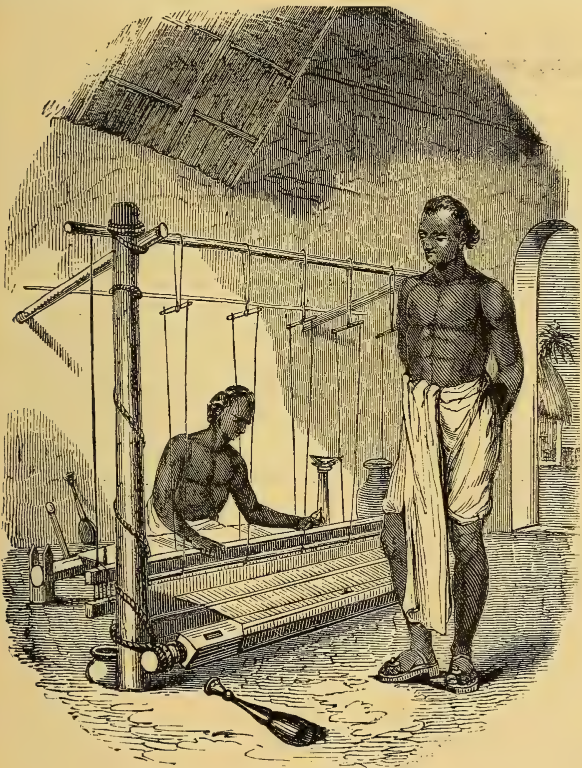


FIG. 10.—INDOOR INDIAN WEAVER.

pendant loops hanging from them. The lay is grooved both in its cap and bottom for the reception of the reed, exactly according to the most modern practice, and the range of its action is controlled by a very simple appliance.

The shuttle bears a great similarity to the English shuttle, though it is somewhat longer and flatter. It is composed of the wood of the betel-nut tree, and is tipped with iron. The eyelet for the passage of the weft is at the side. The cloth is "templed" as in the old manner in this country, the temples consisting of two bars of wood arranged partially parallel, and having pins upon their extremities which are inserted into the edges of the cloth, which is then extended by the rods being pressed down upon it.

In many cases the Indian weaver digs a pit or hole, over which the warp is extended. To weavers in this country the purpose of this pit is not quite obvious, but in the hot climate of India it was of great utility. Its use was, and is now, to secure a degree of humidity for the warp by keeping a well of cool moist air beneath it, the moisture being obtained by the tendency of water to drain into the excavation. In Eastern lands, where the "sizing" was very light, the finer cotton yarns could not have been woven without some such provision during the hot season. Those who remember hand-loom weaving in the cotton trade in this country will know that clay floors in the weaving shops and cellars were very common if not universal, and that in these there was very generally a "treadle hole," into which it was a common practice for the weaver to pour water, especially in summer. Possibly this was a reflection of the system pursued in India, from which it might have been imported when the cotton manufacture of this country was in its infancy. The natural humidity of our atmosphere, however, rendered this provision a superfluous one except on rare occasions, or where the weaving apartments were exceptionally dry.

In the Dutch possessions of Sumatra, Java, and their other provinces, a still ruder form of the loom is used, as was shown at the Amsterdam Exhibition, 1883. This loom consists simply of two bifurcated posts, like a musical pitch-fork in form, which are stuck into the elevated floor

of their dwelling, the open ends uppermost. Into these the beam is inserted, the gears are attached to a post above, and the warp extended by means of a cord passing around the body of the weaver, who follows her occupation with more facility than could be expected from her simple appliances.

In Japan an almost identical loom and method of

FIG. 11.—A JAPANESE WEAVER.

weaving is in use, as may be seen from the accompanying illustration (fig. 11). Passing from Japan to the still more distant Salomon Islands, off the coast of New Guinea, there is found a very crude form of loom used by the natives in making grass cloths. It is shown in fig. 12. A portion of woven cloth is shown at A. This specimen was obtained from Santa Cruz, one of the group of islands. For the use of this and the preceding illustration, which are from the "Voyage of the Nyanza," a work

by Captain J. Cumming Dewar, published last year, we are indebted to Messrs. Blackwood and Sons, publishers.

The succeeding illustration, fig. 13, is reduced from a drawing in Du Chaillu's book, "A Journey to Ashango Land."

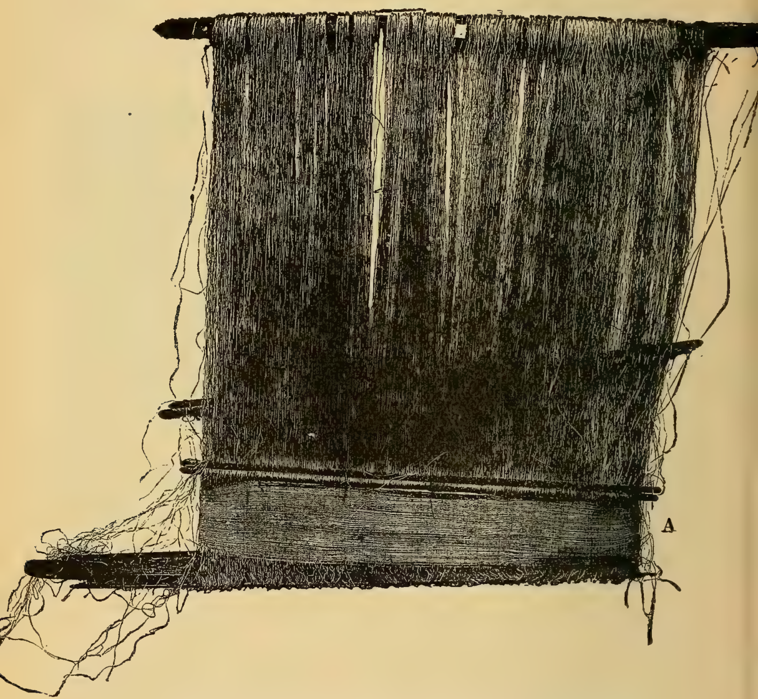


FIG. 12.—LOOM FROM THE SALOMON ISLANDS.

It represents an Ishogo weaver at work making a cloth from the fibres of the palm leaf, which are prepared by the natives with considerable skill, woven into a cloth on the very rude vertical loom shown in the drawing. "In walking down the main street of Mokenga," says the traveller,

"a number of oundjas are seen, each containing four or five looms, with the weavers seated before them weaving the cloth. In the middle of the floor a wood fire is seen burning, and the weavers are sure to be smoking their

FIG. 13.—AN ISHOGO WEAVER; ASHANGO LAND, WEST AFRICA.

pipes and chatting to one another whilst going on with their work. They are all men, and it is the men who stitch the bongos or pieces of cloth together to make robes of them." This cloth is sometimes striped, or even

checked, these effects being obtained by means analogous to those employed by ourselves. The "oundjas," it may be observed, are the workshops of the natives, consisting simply of a roof on posts. They are without walls.

This illustration strikingly elucidates the process of working the Santa Cruz loom, and though derived from lands many thousands of miles apart, the looms are practically identical. The weaver, it will be seen, sits with a supply of grass weft upon his knees, from which to refill his shuttle when exhausted. To those readers to whom Manchester is accessible, we would observe that a loom of the same kind as these obtained from New Caledonia, which is not far from the Salomon Islands, can be inspected at the rooms of the Manchester Geographical Society, 44, Brown Street, Manchester.

It would not be a difficult matter to adduce illustrations to such an extent as to show that the historical development of the loom, as in the preceding pages it has been endeavoured to be traced, could be paralleled on geographical lines: that is, that all the phases through which the loom has passed from its inception to its present degree of perfection, can be found existing to-day, and employed for industrial purposes.

Returning from this digression, the last two advances made in the hand-loom may be noted. At the beginning of the eighteenth century the productive capacity of the spinner and the weaver were in a state of equilibrium: the latter easily consumed what the former produced without the first being overburdened with stocks or the second having to wait for supplies of yarn. But a disturbing element had been introduced into the political, commercial, and industrial relations of England, that began then, and has continued ever since, to exercise the most important influence upon its fortunes and destiny—an influence, of the disappearance of which no sign as yet is visible. This was the foundation of the East India Company during the reign of Queen Elizabeth, and the esta-

blishment of numerous commercial factories, and the growth of trade between that country and England. The introduction of Indian cotton fabrics led to a demand which steadily grew, until it had attained such an extent as seriously to alarm those engaged in the textile industries, the dissatisfaction being most concentrated at Norwich, the principal centre of the weaving industries at that time. In 1700 printed calicoes were prohibited by statute from being introduced or worn in the country, but this proved of little avail, as eight years later we find De Foe, in the "Weekly Review," deploring the growing popularity of cotton goods, asserting that it had practically ruined half of the woollen industry of the country. The demand continued to extend, though numerous impediments were placed in the way of its gratification. Weavers also endeavoured to compete with the Indian fabrics by making light goods in both wool, flax, and unions of these materials. The use of cotton was hated so much as to be prohibited in mixed goods. These fine light fabrics could not be woven with the same facility as the rough, coarse, and heavy goods that had been displaced; hence there existed a large and growing demand, that was bound, in the then condition of the industry, to remain ungratified. This may be regarded as the stimulus that led to the next step in the development of the loom—the invention of the fly-shuttle by John Kay, a native of Bury, in Lancashire. Kay was the son of a woollen manufacturer of that town, who had also an establishment at Colchester. After being brought up to the trade in Lancashire, young Kay, who had shown considerable mechanical ingenuity, was sent to the southern town, to take charge of his father's business, and it was while residing there that he determined to accelerate the weaving process, which he accomplished by the invention of his system of throwing the shuttle, and on which his reputation is founded. This important improvement, where adopted, at once quadrupled the power of the weaver, whilst it obviated the necessity of employing two weavers

upon wide looms, thus setting a large number at liberty to operate looms for themselves. The invention consisted in the addition to the ends of the batten or lathe of two boxes, for the reception of the shuttle in place of the weaver's hands, previously held out to receive it. In each of these boxes a spindle extending their length was fitted, termed the fly-spindle, and each carried a shuttle-driver, or "picker," as they were technically termed. Between these a cord was extended and attached to each, and affixed to this cord, in the centre of its length, was the peg, or "picking-stick," as it is usually called in Lancashire, by means of which the shuttle was jerked from one box to the other through the open shed of the warp. This constituted Kay's great invention; and simple though it may now appear, few have equalled it in the important consequences that have flowed from it.

The details of a common fly-shuttle loom are shown in fig. 14, which is from Dr. Ure's "Cotton Manufacture of Great Britain." The warp beam, with the warp upon it, is shown at A; the lease rods ought to have been seen at B, but the artist has failed to depict them; the two leaves of heddles are shown at C and D; the reed is carried in the lathe, forming the cross-bar carried by the vertical supports, E, the whole swinging upon the cross-bar, F; G is the weaver's seat, often called "the sitting-tree;" sitting upon which, with his feet he operates the treadles, H, alternately pressing down one and then the other, whilst between each movement he projects the shuttle through the open warp, and then pulls the lathe towards him to bring home the last pick to the fell of the cloth, that is, the pick last laid.

The invention of the fly-shuttle was the initial step of the great industrial revolution constituted by the change from the manual to the mechanical systems of labour, which has been in steady progress through, and will for ever in the pages of history distinguish, the eighteenth and nineteenth centuries from all those that have gone

before, and probably from all that will follow after. It is not intended to place limits to the conquests of the human mind, but it is more likely than not that the chief victories that are to follow will be won in other than mechanical fields.

The balance that had hitherto existed between the spinning and weaving branches was now rudely disturbed. This will be evident when it is stated that in the woollen

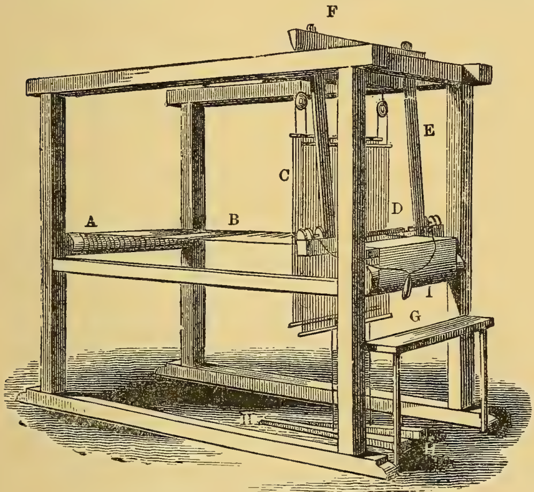


FIG. 14.—KAY'S FLYSHUTTLE LOOM

trade at this time one weaver required, in the other sections of the industry, to prepare for and finish after him, the services of twelve other persons. It may be interesting and instructive to give here a statement from the "case" of a Norwich weaver against Manchester calicoes, published about 1720, and quoted in Mr. Alfred Barlow's "History of Weaving," from which it is extracted. In relation to the rest the weavers, it appears, stood as follows:—

Weavers	100
Wool sorters	4
Pickers	10
Combers	20
Spinners	900
Throwers	4
Twiners of the throwing mill	4
Thread makers	4
Doublers	50
Bobbin winders	12
Back-throw winders	12
Quill boys	50
Warpers	5
Dyers	6
Pressers	6
Total	1,187

Thus it will be seen that an invention like that of John Kay, which quadrupled the capacity of the weaver, and largely increased their numbers by liberating one from every broad loom to weave for him or herself, radically altered the conditions of the industry. The change, however, was not instantaneous, as Kay's invention met with great opposition amongst the weavers of Colchester, where it was first introduced. Kay brought the invention northwards to Lancashire, his native county, where it met with a more favourable reception, and was speedily carried across the borders into Yorkshire, and generally adopted. It is not necessary to inquire further into its effects, or into the manner in which its inventor was defrauded of the reward that was his due. Kay had considerable mechanical ability, as is well proved by his numerous other inventions, and this ability was inherited by his son.

No further development of the hand-loom is heard of until John Kay's son Robert invented the drop-box in 1760. This invention consisted of an arrangement of

several shuttle-boxes at one or both ends of the lathe, whereby the weaver is enabled to introduce with facility into his fabric several colours or counts of yarns, by which the cloth was striped across its length. When the warp was striped in a corresponding manner a checked effect was obtained. The apparatus is shown in the illustration, fig. 15. The cross-bar, A, is sustained upon iron gudgeons on the loom frame, which is shown in section. From this bar the lathe depends by means of its swords, B B. The lathe beam, C, carries the reed. The shuttle-boxes, D D, are shown suspended in their respective frames. The

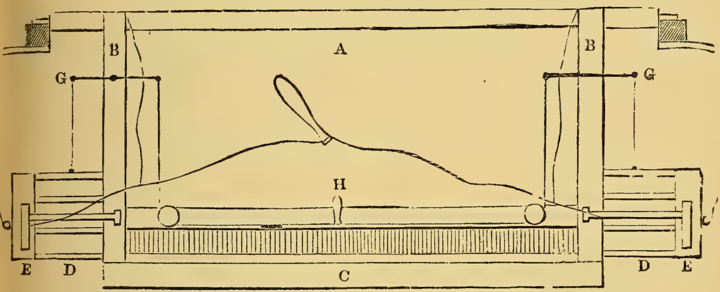


FIG. 15.—ROBERT KAY'S DROP-BOX ARRANGEMENT, 1760.

fly-spindles, each carrying its respective picker, with the picking-cords attached, have the latter rudely delineated at E E. The horizontal levers, G G, moving upon their centres upon the lathe-swords, B B, are connected with the boxes by the means shown, the latter being actuated by the weaver pushing the pin, H, to the right or left upon the lathe-cap or bar, by which action the levers, G G, through their connections, bring any required box opposite the shuttle-race, ready to deliver any shuttle it may contain, or if empty, to receive any that may be directed to it. This may be regarded as the last considerable improvement made in the hand-loom, and it was fit that it should have been

accomplished by the son of the man whose inventive genius first gave to the world a fore-gleam of the possibilities of mechanical industry.

This practically closes the chapter of the hand-loom's history. It will be observed that up to this time there was hardly any thought of the loom being made to supersede the operations of the weaver. Nearly all that had been sought, or even conceived, was to facilitate his actions in the labour of weaving. To make the machine imitate and perform these actions equally well, or even better, had not entered into the mind of more than two or three men at the most, so far as appears from any record that remains. But the time was drawing near when the conception was not only to arise, but to be realized by the person to whom the thought occurred. The story of its inception and development will form the subject of the next chapter.

CHAPTER III.

The Power-Loom and its Development.

Poverty of early mechanical science; late development of man's inventive faculty.—The equilibrium in the productive capacity of the spindle and the loom at the commencement of the eighteenth century; deranged by John Kay's invention.—The position reversed by Hargreaves' and Arkwright's inventions.—M. de Gennes' and Vaucanson's automatic looms; failure of both; unfavourable circumstances.—The Barbour Brothers' improved hand-loom.—Cartwright at Cromford propounds the idea of the automatic or power loom.—Endeavours to realise it; his first attempt and failure.—Examines hand-loom weaving and begins anew.—His second attempt, and its wonderful approximation to success; attempting too much the cause of his failure.—Description of his loom.—His subsequent improvements.—Further developments of the loom.—Clark's improved slay.—Gorton's over-pick.—Miller's wiper loom.—Johnson's dressing frame.—John Todd's improvements.—William Horrocks' improvements.—His dandy loom.—Further improvements and alterations by various succeeding inventors.—Richard Roberts and his important inventions and improvements in the loom.—Full description of Roberts' loom.—Automatic stop-motions for warp and weft threads.—William Dickinson's Blackburn loom.—His improvement of the picking motion.—Inventors upon false tracks.—The draught and pacing motions.—Smith's scroll pick.—Kenworthy and Bullough, the Blackburn inventors.—The automatic weft slop-motion; Ramsbottom and Holt's double vertical loom.—James Bullough's double horizontal loom.—Parkinson's disc temple.—James Bullough's improved weft-fork arrangement, and trough and roller temple; description.—Clinton G. Gilroy's claim to the former examined.—The power-loom in principle now a perfect automaton, and an economical success.—Its further improvement by a multitude of inventors.

LOOKED at from the present advanced position of textile mechanics, attained after a century of unparalleled inventive efforts, the slow and halting steps made by

mechanical science in the many centuries comprehended in the previous review would justify the conclusion that the inventive faculty of man's nature constitutes a recent development of his intellectual powers, equivalent to the acquisition of a new sense. Even yet the capability is almost confined to two or three European peoples and their descendants in other lands. The great results achieved by these nations have had little or no effect in stimulating the manifestation of the faculty amongst other communities. The skill of Eastern races seems to have spent itself in achieving the most perfect results of which manual processes are capable. The products of Indian, Chinese, and Japanese arts, especially in textiles, in excellence of colouring, variety, beauty of design, and perfection of execution, are something that the mechanical productions of the West are a long way from equalling, but to which they may with advantage aspire. These are thoughts that would lead to some interesting speculations if followed, but such a divergence would be out of place in the present essay, and the temptation therefore must be resisted.

The reader will recall the fact stated in the preceding chapter, namely, that a condition of practical equilibrium existed between the various sections of the textile industries at the close of the seventeenth and the beginning of the eighteenth centuries: that is, the productive power of spinners in supplying yarn was about equal to the capacity of the weavers to consume it. The conjoint labours of the two, however, were unequal to meet the growing demand of the people for finer and better textiles, which began to be supplied from India. The imports from this source were, however, interfered with by legislative enactments, which were passed at the instance of manufacturers. Kay's invention of the fly-shuttle increased the disorder arising from the growing competition of India, and its extended adoption intensified the disorganization to such an extent that one of the most pressing

wants of the time was the weaver's want of weft. The details of this phase of the history of the cotton trade, and the efforts of invention to overcome these difficulties, and which ultimated in the brilliant success of Hargreaves of Blackburn, Arkwright of Preston, and Crompton of Bolton, are given in the writer's former work "Cotton Spinning: its Development, Principles, and Practice," to which the reader who may be interested therein is referred.

The extending adoption of Hargreaves' jenny in the homes of the spinners and weavers; the successful establishment of Arkwright's spinning mills at Cromford, Masson, and other places; and of those of other people in various parts of the country, in which the machinery of the great inventor was worked under a royalty, led to a well-founded apprehension that from a great scarcity of yarn the country was passing to a state of superabundance, that would be even more disadvantageous than the previous deficiency. This idea became in a few minds the parent of another, that the loom ought to be improved; and recent researches into the story of its mechanical development have led to the discovery of several attempts to carry into effect the vague conceptions that, with more or less distinctness, had thus grown up. These must be noticed very briefly.

It is somewhat singular that the first attempt to make an automatic loom yet discovered occurred half a century before Kay invented his fly-shuttle. It appears to have been made by one M. de Gennes, an officer of the French navy, who presented the machine embodying his conception to the Royal Academy of Paris, in 1678, and a description, with an illustration, was published in No. XXXII. of the "Journal des Sçavans" in that city in the same year. It was termed a new machine for making linen cloth without the aid of a workman. Those who may be desirous of learning more of it will find an illustration in the Introduction to the "Abridgements of Specifications for Weaving," Part I. (1620-1859). It is very interesting,

and to the student well worth perusal. This germ, however, perished, leaving no influence behind.

The next attempt which has been brought to light was also of French origin, and was made by Vaucanson in 1745. His loom contained the rudiments of the celebrated invention of Jacquard, and also of the friction roller taking-up motion still universally in use. It is curious to observe that both this and the former invention of De Gennes had a shuttle motion, consisting of levers having sockets at their extremities, which passed the shuttle alternately from one to the other through the open shed of the warp. This, on the part of both inventors, was clearly an attempt to imitate the action of the earliest weavers and the function of their hands in passing the shuttle through the shed of the warp. But later weavers threw their shuttles from hand to hand: these levers, if the expression may be permitted, handed the shuttle alternately from one to the other. It will be obvious that the best speed that could possibly be attained would be less than that of the ordinary weaver even of that time. It may be remarked, in passing, that the present writer saw a loom constructed on this plan in the Paris Exhibition of 1878, made by a Swiss machinist. It could hardly have been intended to be more than a mechanical curiosity. Kay's plan of throwing the shuttle had been invented twelve years, but had evidently not come under the notice of Vaucanson, otherwise, as Mr. Alfred Barlow in his "History of Weaving" remarks, "he might have adopted it, and had he done so the power-loom might have made its way half a century earlier than it did." The result in this case was the same as in the preceding one.

At the time under notice, however, there was no strong motive to increase the capability of the weaver, and had any ingenious inventor succeeded at this time in making an automatic loom of a capacity exceeding that of the hand-loom, it would have had small chance of being adopted, as

already the power of the spinner to supply weft was being left in the rear of the weaver's capacity to consume it, owing to the extending use, by the latter, of Kay's invention But the time was drawing near when all this was to change. In 1764 Hargreaves achieved his grand success in the invention of the spinning-jenny, and Arkwright quickly followed in his steps. A few years served to revolutionize conditions, and yarns from being very scarce became relatively abundant. It was this which gave rise to the impression referred to above. The first outcome of the idea was the attempt of "Robert and Thomas Barber, of Billborough, Nottingham, gentlemen," who, in 1774, took out a patent, No. 1,083, for machinery for preparing, spinning, and weaving fibrous substances, &c Mr. Barlow, in the "History of Weaving" before referred to, p. 231 gives both details and illustration, to which the reader is referred. This loom was wonderfully near being a solution of the problem conceived, and had its inventors possessed the persistency of purpose of Dr. Cartwright, there can be little doubt that their success would have been assured, as their device was a much better and more practicable one than the first effort of the clergyman's. Nothing, however, so far as can now be learned, was heard of it further.

These were the droppings, of no significance to blind eyes, preliminary to the showers of the inventive faculty that were about to fall upon the world, and which were abundant and full of meaning and promise for the highest interests of mankind.

The sentiment of which we have just spoken had in no sense been allayed when, in 1784, a party of gentlemen are stated to have met at the dinner table of an hotel at Matlock Bath, closely adjacent to Cromford, the seat of Sir Richard Arkwright's mills, who engaged in a discussion of the prospects of the then infant cotton trade; and, as has oftentimes been done since, debated the consequences that would ensue from the over-production of

yarns that was held to be likely to arise from the then existing numbers and prospective increase of the newly invented machines. It was in this discussion that the brilliant idea was expressed that if we made machines to spin yarn we must make machines to weave it. This grand conception was put forth by the Rev. Dr. Cartwright, a clergyman of the Church of England. The company which was thus engaged in conversation included several gentlemen from Manchester, who might fairly be esteemed to be capable judges of the subject. These declared the idea to be quite impracticable, owing to the number and complexity of the movements of a weaver when at work. The rev. gentleman, however, strongly argued in favour of its possibility, and in proof of the position he had taken up, adduced in illustration and instance the automaton chess player, which was about that time attracting much attention in London. Of the effect of his arguments upon his hearers the records tell us nothing, but it is certain that he convinced himself not only of its practicability, but of the great desirability of its being done; and, greatest conviction of all, that he was the man to do it. Had the worthy doctor done nothing more than broach this magnificent idea he would have deserved to he held in grateful remembrance; but as he at once proceeded to carry it into effect his deserts in this respect are all the greater.

Dr. Cartwright returned home, and immediately set about the realization of his novel scheme: novel it may truly be called, because it has nowhere been alleged, nor is there any reason to believe, that either he or any members of the company before whom he projected it had ever heard, in any manner, of the attempts made by the persons whose names have been given before. As he himself subsequently confessed, he knew nothing whatever of weaving, never even having seen a weaver at work. Of the stages of his progress no record is left, but after a few months' struggle he had brought his thought so near to realiza-

tion that he took out a patent in order to secure the large profits he anticipated would accrue from the invention. This was in April, 1785. It is worth while to describe this first device, notwithstanding its crudeness, being, as it was, the parent of the large number that has followed it on the same subject. The illustration, fig. 16, and the

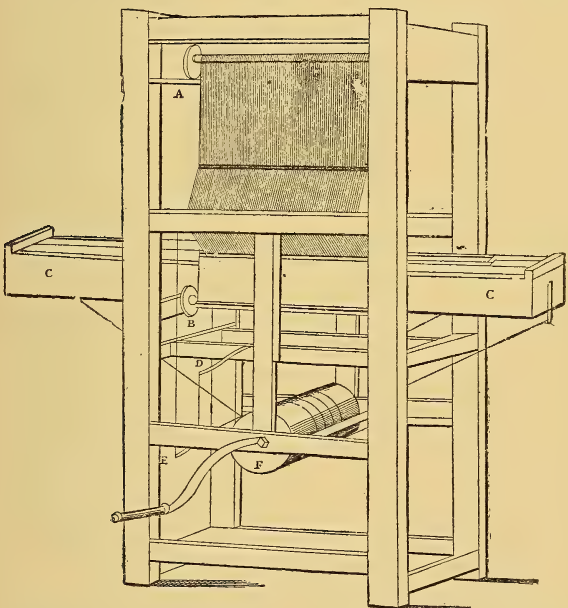


FIG. 16.—CARTWRIGHT'S FIRST POWER LOOM, 1785.

details are from the patent specification, wherein it is thus described by the patentee :—

"It is worked by a mechanical force. The warp, instead of lying horizontally, as in the common looms, is in this machine (which may be made to hold any number of webs at pleasure) placed perpendicularly. The shuttle,

instead of being thrown by hand, is thrown either by a spring, the vibration of a pendulum, the stroke of a hammer, or by the application of one of the mechanical powers, according to the nature of the work and the distance the shuttle is required to be thrown; and, lastly, the web winds up gradually as it is woven.

' A is the warp beam; B the cloth beam; C C the boxes containing the springs that throw the shuttles; D is a lever, having a corresponding one on the opposite side for elevating the reed or comb; E a lever, having a corresponding one on the opposite side for reversing the threads; F the cylinder which gives motion to the levers. N.B. The warp is kept to a due degree of tension by the counteraction of either a weight or spring. The web is made to wind by a like power, though in an inferior degree, and is prevented, as the stroke of the reed or comb brings it down, from unwinding by a ratch-wheel and click."

It is curious to observe that this is a vertical loom The reverend gentleman's ignorance of the art of weaving, and the appliances common in the industry, from a contemplation of the nebulous result of his first effort, will be very obvious to all modern readers. When he had, as he thought, completed his task, he condescended to see how other people wove. He went to watch some handloom weavers at work, and was surprised to find how easily and with what little expenditure of energy they performed their task. His loom could only be worked by two strong men, and that for only a short time at once. His lathe for beating up the weft fell with a weight many times greater than necessary, and with such force as must tear all his warps to pieces. It was an instructive lesson, and was not lost upon him. He returned home with more knowledge and wisdom, and resolutely set himself to devise a fresh solution of the problem.

In his new design Dr. Cartwright adopted the common wood frame of the hand-loom, and with it the horizontal arrangement of the warp. In doing this he acted wisely,

because the general prevalence of this form of the loom, which was the outcome of the experience of nearly all ages and countries, was an incontestible demonstration that it was the best. But he did, or at least attempted, much more than this. A study of the art of weaving, as he saw it practised, revealed to him many details, of which he was before entirely ignorant. It is curious to contrast the enlarged and comprehensive conception of his task, as exhibited in the ample and widely different details of his second specification, with the meagre and crude notions embodied in his first. In the latter he overshoots the mark quite as much as before he fell short.

In the domestic form of the industry the weaver performed many tasks for himself that, with its advancing improvement, have successively been detached from his charge and have become separate pursuits. Some of these may be mentioned, as warping, beaming, and sizing; all these processes, besides the movements incident to weaving merely, Cartwright attempted to combine and perform in his automatic loom. And when it is added that he included a positive taking-up motion for the cloth and letting-off motion for the warp, and also a broken-weft stopping motion, and a broken-warp-thread stopping motion, the reader will conclude that he attempted too much, and no wonder will be felt that he failed. As it is on his foundation that the wonderfully perfect automatic loom of the present day is built, it will be interesting to the student to examine the embodiment of the inventor's idea in some detail, means for which is afforded in the annexed illustration, fig. 17, which is a reduction of the drawings accompanying his specification of October 30th, 1786. We may premise that the drawing is crude and imperfect, showing a want of skill in mechanical drawing. The view given is, however, accompanied by a number of drawings of details, but the task of combining them in one machine must have been very difficult. The language in which the specification is drawn is as crude and incomprehensible as the drawings,

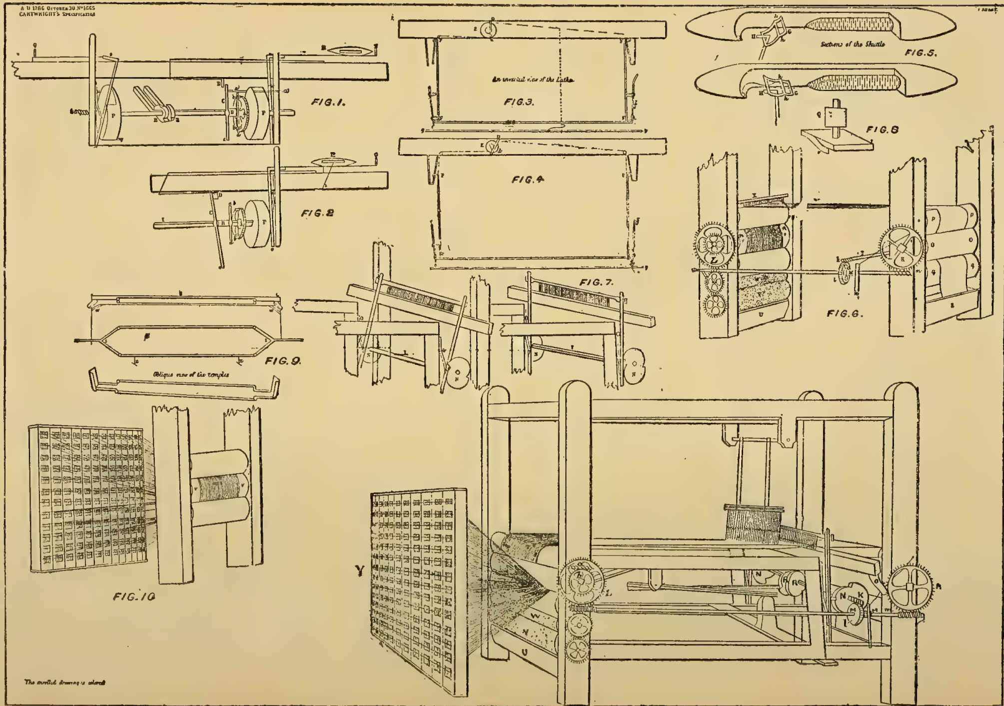


FIG. 17.—CARTWRIGHT'S SECOND LOOM AND DETAILS, 1786.

and would need the expenditure of much more time and patience than the average reader would be likely to give to get approximately near its meaning. This being the case, the writer prefers to submit a paraphrase of it, which he hopes will remove most of the obscurity in which Dr. Cartwright's meaning was hidden, whether intentionally or otherwise it is not necessary to inquire.

It will be observed that the inventor has adopted the ordinary hand-loom frame. Instead of the common single beam for the warp, he has substituted a yarn bobbin frame, from which the cloth can be woven, he says, "without the trouble of winding, warping, or beaming." It will be remembered that it was customary for the hand-loom weaver to size or "dress" his warp in the loom in lengths from near the healds to the warp beam. This practice the learned doctor endeavoured to obviate by inventing the automatic arrangement shown in the illustration, which consists of a trough extending across the loom at the back to contain the sizing mixture, which it may safely be presumed was of much lighter consistency than that now ordinarily used. The first dotted cylinder above the trough represents a brush working in the size mixture, and conveying it in the course of its revolution to a second brush next above it and similarly delineated, which in turn gives it to the roller above, while the latter conveys it to the warp in its passage. The first-named roller may be called the sizing roller, and the top one the compression roller. Passing between these two the warp returns over the latter and passes upward over the carrier beam and onward to the healds. Over the top of the carrier beam a flat dry brush was arranged for working the "dressing composition into the yarn, and laying the filaments of it smooth," but this is not shown in the illustration. The latter is also defective in not showing the taking-up arrangement, given in one of the detail drawings, which consists of three "cylinders" or rollers placed one above the other, the middle one acting as the motor. The cloth

as woven passed over the first, around the second, coming back between the latter and the third, and instead of being wound upon the last-mentioned was delivered into a box or trough beneath.

We now come to the mechanism of this remarkable loom. The "slay" or lathe, instead of depending from the upper cross rails of the frame, as in the ordinary hand-loom, has this arrangement reversed, and oscillates upon two standards or primitive "swords," and, it may be presumed, a rocking-rail at the bottom. This arrangement was necessary in order to actuate it conveniently. The main or first shaft crosses the frame in front of the lathe, and carries the two cams which operate it, also the two cams that actuate the under-pick picking-sticks, and in the middle the tappets for shedding. All these are in one way or another eccentric. The shedding tappets and the lathe cams are shown in the illustration, but those working the picking arrangement are left out, it apparently having been beyond the skill of the artist to show one cam behind another. The shuttle was projected through the shed by springs compressed into position by the revolving cams, and acting upon the picking-rods, when released from the detent of the cam. The picking, shedding, and the actuation of the slay being all performed from the first, and indeed the only shaft, for there is no shaft in the loom analogous to the second shaft of the modern loom, it will be obvious that the cams employed needed to be of a very peculiar construction, and, as shown, may be termed double eccentrics. It will be clear also that the movements that could be obtained from such arrangements would at the best be unsuitable for the purpose, as they must have been hard, harsh, and to use the next word in its strictly literal sense, shocking. There could be nothing in it of the easy gliding from one position and one movement to another, so necessary to the preservation of the yarn and the durability of the machine, and which is so characteristic of the almost perfect loom of to-day.

Keeping to the details shown in the illustration, the next movements calling for notice are the taking-up and letting-off motions. These are both of the positive order, and are directly connected. It will be observed that on the extremity of the first shaft there is a projection, carrying a worm gearing into a wheel upon a cross shaft, which extends from the front to the back of the loom frame on the outside. On each extremity of this shaft is a worm, that on the front gearing into a wheel on the taking-up roller, and that at the back into a wheel on the warp delivery roller, and also operating through a pair of wheels the two sizing-brush rollers. By changing the sizes of one or both of the two first-mentioned wheels the inventor altered and regulated the number of picks he put into his cloth. It hardly needs pointing out to any one familiar with the loom that he would experience a considerable amount of difficulty in doing this to his satisfaction by such appliances. It may be also observed that it was, probably, owing to Dr. Cartwright's unfamiliarity with weaving operations that he ignored the excellent warp-pacing or letting-off arrangement of the rope and weight which had long been in use in his day in the hand-loom, and upon which inventors have found it difficult to effect any improvement.

There was also incorporated in this loom an automatic stop-motion for stopping the loom when the weft broke. The principal mechanism for effecting this was a swivel plate inserted into the shuttle. This in form somewhat resembled a buckle of three bars, and had its pivot in the centre one. The bars were not, however, equi-distant, the one nearest the shuttle-eye being further distant from the pivot-bar than the one nearest to the shuttle-peg. The weft-thread was passed through the openings in this buckle, and the tension upon the weft while at work maintained it in a horizontal position. Immediately upon the breakage of the weft the larger end dropped down, and on emerging from the shed caught upon a hook, and thus, through suitable mechanism, brought the loom to a stand.

So far as we can make out this was a very imperfect embodiment of an excellent idea, which has since been perfected in an ingenious and beautiful manner.

But even this did not satisfy the comprehensive mind of the reverend inventor. He endeavoured to construct an automatic stop-motion which should stop the loom on the breakage of the warp-threads. It will suffice to say regarding this, that though probably quite ineffectual in this instance, and serving only to unnecessarily complicate the loom, it has since been perfected and embodied in the modern self-stopping beam warping mill, in which the essential part is the drop-wire. The doctor was also, in this instance, in advance of the time ; this part of his self-imposed task even to-day, so far as commercial success is concerned, remaining an unsolved problem as applied to the warp in the loom. It has been solved, but not yet with sufficient simplicity and economy to obtain the wide adoption of any of the methods yet invented. It may be observed, in concluding this notice of Dr. Cartwright's loom, that no means of connecting it with any motive power, is shown in either the full or detailed drawings.

Such are the leading features of this important invention. Its minor details it would serve no useful purpose to describe. The three subsequent patents of the same inventor refer to improvements in various points which bring the several details nearer in principle to modern appliances than they were in their original form. It may now be well to trace succinctly and as briefly as possible, compatible with justice to the subject, the further development of the loom until it is found embodying all the principles and details necessary to render it a perfect automatic machine.

The idea of mechanical weaving having thus been broached, and demonstrated to be practicable, progress, though slow, was steady for some years, as many inventors entered the new field thrown open for the exercise of their ingenuity. Contemporaneous with Cartwright was

"Thomas Clark, the Younger," who, in improvements patented in 1788, advances the lathe by pulleys revolving in arms fixed to a square piece of wood upon the driving-shaft, and brings it back by wood springs. This is apparently the beginning of the "wiper" principle. The same inventor introduces the warp-pacing arrangement of the hand-loom, the lever and weight ropes, which Cartwright made a mistake in not adopting at once. He wisely discards the latter's attempt to make a warp from a creel of bobbins. He also makes provision to prevent the breakage of the warp by the trapping of the shuttle, to obviate which it may reasonably be suspected Dr. Cartwright had found to be one of his greatest difficulties. Clark's method is to suspend the warp carrier beam from cords passing over pulleys, balancing it by weights. In the event of a shuttle being caught in the shed, the strain upon the warp would draw down the beam and slacken the warp to such an extent as to prevent its being broken. It is not many years since inventors abandoned plans on this principle for obtaining the same end.

In 1791 Richard Gorton introduced the old over-pick, in which the picking-stick is attached to a stud on the lathe, and is connected by cords to a picker on each side of the loom, in this imitating the action of the hand-loom weaver, using John Kay's invention of the picking-stick, by which the weaver threw the shuttle alternately one way and then the other by a forward and backward jerk of the hand. This system is still in existence in some of the old woollen and worsted power-looms in Yorkshire, but has long ago disappeared from the cotton trade. He also furnished the shuttle-box with the swell spring to retain the shuttle, and the stop-rod and frog, both of which are still extensively in use. He adopted Cartwright's plan of sizing the warp by means of trough, brushes, and roller.

Robert Miller, of Glasgow, in 1796, introduced the improvement of taking up the cloth as woven by means of two rollers worked by a ratchet-wheel and catch, "fastened

to a lever worked by a cam on the main shaft." The first part of this improvement is in universal use to-day, the only change that has occurred being in the means of actuating the rollers. In the same specification the inventor brings forward another excellent appliance in the lever-picking motion, which subsisted with improvements until about 1855. Other devices were included, but from the description given of them it is safe to infer that they were substantially impracticable. This was the celebrated wiper loom.

Seven or eight years passed before any further advance was made, which then came in the shape of an invention by Thomas Johnson, of Stockport, in 1803, of the dressing-frame, which finally emancipated the weaver from the task of sizing his warp in the loom. This necessity and complication of the weaving process had been a great stumbling-block to the progress of the improvement of the loom. It is not necessary to describe this invention in this place; neither, as sizing now branches off into an independent industry, is it requisite to note its further progress in this review of the development of the loom.

In 1803 John Todd, presumably of Burnley, introduced the heald roller, placing it on the top of the loom, and attaching the healds thereto by cords, working them by treadles actuated by cams upon the second shaft. The lathe is moved by a crank working in a slot in the lathe swords. The stop-rod for the latter, as described before, is included. This heald roller and the new shedding arrangement constituted a great advance.

The improvements of William Horrocks, of Stockport, patented also in 1803, brought the power-loom appreciably nearer to being a commercial success, though still leaving much to accomplish. In this case the old wooden frame of the hand-loom was retained, and the lathe was pendant from the top cross-beams, and was operated from cranks on the first shaft, the shedding being performed by tappets on the second shaft. An improved taking-up

motion for the cloth was introduced, which was said to be a piracy from one invented by William Radcliffe, also of Stockport, the year previous, and brought before the trade embodied in that inventor's well-known "dandy loom." This was a remodelled and greatly improved hand-loom; it was substantially the last attempt to improve it.

After the above date there was much labour, but little achievement of value, for the space of twenty years. As the inventions that were patented during that time have left little or no mark of a permanent character upon the structure of the power-loom, it will serve to enumerate their principal objects, as these will show the directions in which the inventive genius of the time was labouring. In 1806 Peter Marsland introduced a slow movement of the lathe during the passage of the shuttle. This was obviously to overcome the difficulty induced by a poor picking arrangement. It was, however, beginning at the wrong end. In 1807 Thomas Johnson set aside the principal experience of ages, and constructed a vertical loom, thus reverting to an ancient form. Little was heard of this, so far as can now be gathered. In 1810 William Cotton adapted, as a pacing or letting-off motion, the principle of an invention for another purpose. Peter Ewart, in 1813, first introduced the pneumatic principle into the loom, which he applied for actuating the lathe. Many others since his time have struggled with this principle, though chiefly with a view to utilizing it in the projection of the shuttle. All have hitherto failed to produce any arrangement of commercial value. In the same year William Horrocks patented a plan by which he almost brought the lathe to a stand whilst the shuttle was passing through the shed, thus accenting the principle introduced by Peter Marsland. The waste of power involved in this arrangement will be obvious. In 1815 Joseph and Peter Taylor invented the double-beat foot-lathe, for use in weaving heavy cloths, an invention which has survived in improved form until to-day. It is still in extensive use for

certain fabrics. In 1821 William Horrocks again comes to the front with a plan for wetting the warp and weft during working. This was obviously to overcome the defects of the system of sizing then in use.

We now come to a celebrated name on the roll of English inventors, that of Richard Roberts. Roberts had for five or six years been settled in Manchester, and had achieved a considerable reputation by his inventions in other fields of mechanics, when the firm, of which he was a principal, turned their attention to textile machinery. Roberts' improvements in the loom constituted in their day a very distinct step forward. The most important of these, embodied in the patent grant of 1822, is an improved arrangement and actuation of the taking-up gear, consisting of a toothed wheel placed upon the axis of the cloth-roller, which was actuated by a pinion fixed on the axis of a ratchet-wheel, which was moved by a click jointed to a lever worked by the lathe. This is substantially the taking-up gear of to-day. A positive warp-delivery motion, worked in connection with the taking-up arrangement, is included, the means employed being "a screw and worm wheel, or other similar contrivance." There are several other improvements included in the same specification, relating mostly to the means for the production of fancy cloths and to small-wares in swivel looms. The only one we need notice is an improvement in the means of shedding in cases where more than two shafts of healds are employed. The tappet-wheel he makes to "consist of a number of small rollers or tappets, arranged in the circumference of a circle or revolving wheel, and adapted to operate upon a system of levers, one half of which are elevating levers for the purpose of raising the shafts or heddles, and the other half are depressing levers, for the purpose of depressing the shafts or heddles." This is almost the cylinder-shedding arrangement, well known in the production of fancy fabrics until about the year 1855, when it began to be superseded by

improved appliances, which will duly come under notice hereafter.

Richard Roberts took the power-loom as left by William Horrocks, and upon that built his modifications and improvements. The loom of Roberts occupies a position about midway between that of Cartwright and the comparatively perfect loom of to-day. It will, therefore, be useful to the student if the position at this point be reviewed, and an opportunity be afforded him of measuring the progress made in the interval from Cartwright's laying down his task to the time it was taken up by one of his greatest successors in the same field of invention. The following illustrations and descriptions of Roberts' loom, from Dr. Ure's "Cotton Manufacture," enables this to be done with facility.

"Figs. 18 and 20 are two side elevations, and fig. 19 is a front view.

"Those parts in the engraving marked with the letter A compose the frame-work of the loom. B is the usual outrigger, or fast and loose pulleys, upon the principal or crank shaft. C is a small fly-wheel, for equalising any casual irregularities of motion in the machine.

"Upon the other end of the main shaft is a wheel, D, figs. 19 and 20, driving another wheel, D′, with double the number of teeth, upon the shaft, E, which makes, therefore, only half as many revolutions as the main, or crank shaft, B. The shaft, E, is called the tappet, or wiper-shaft; it raises and lowers the treadles, and throws the shuttle, while the shaft, B, by means of its cranks, F, figs. 18 and 20, drives home the weft towards the finished cloth, or works the batten.

"The cranks, F, are connected with the two levers, G, G, called the swords of the lay, to which the batten, H, is made fast, which carries the reed in its middle, to the shuttle-boxes, *h, h*, at its end. See fig. 19.

"I is the warp-beam. The warp-yarns pass from it over the roller, K, through the heddles, L, through the reed, *l*′,

over the breast-beam, M (having now been changed into cloth). This is finally wound upon the roller, N, or cloth-beam. This roller bears at one end a toothed wheel, *a*,

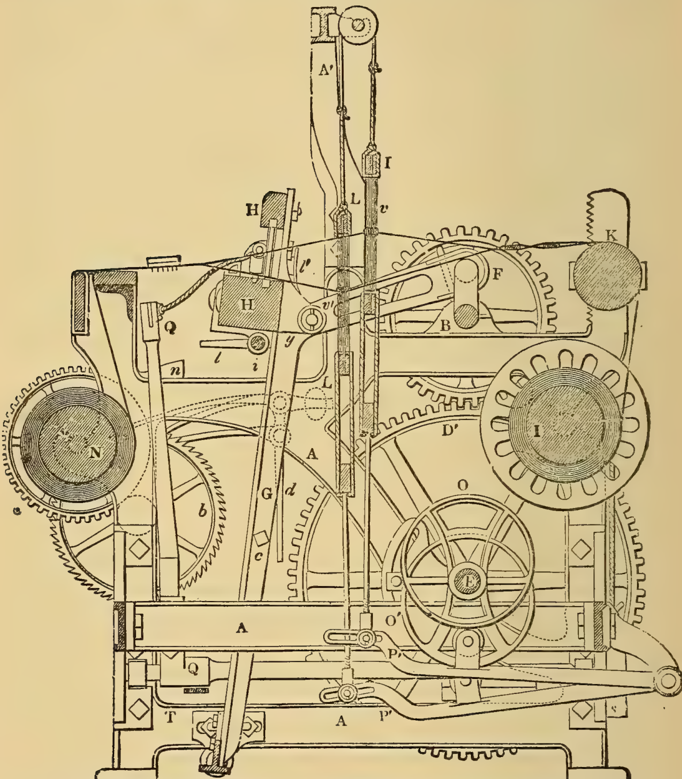


FIG. 18.—ROBERTS' LOOM. "FIRST SIDE ELEVATION;" 1830.

which is moved slowly by a small pinion, *u* (fig. 18), upon the axis of the ratchet-wheel, *b*. This latter wheel is turned round a little after every throw of the shuttle, or shoot of the weft, by means of a shed, *c* (figs. 19 and

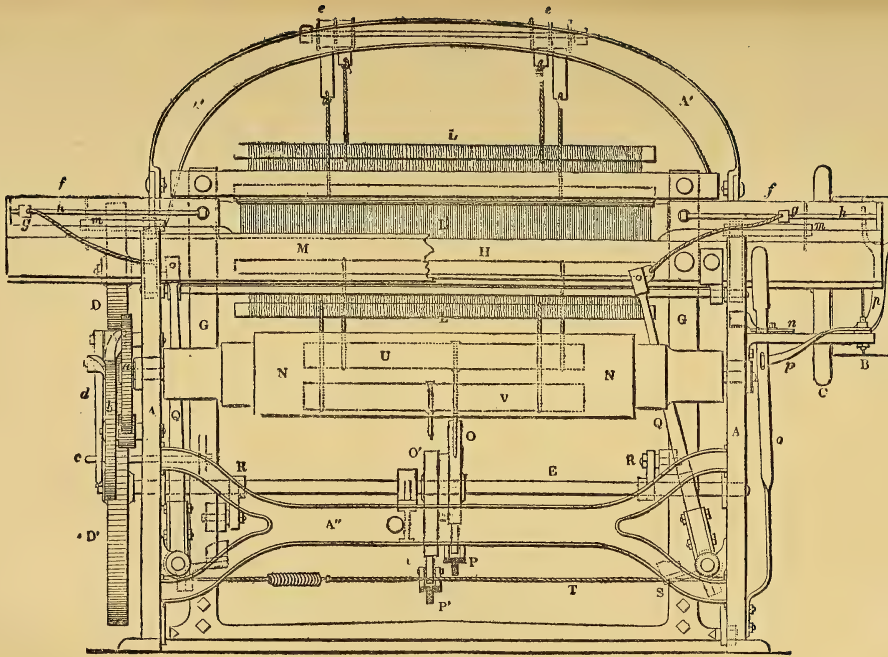


FIG. 19.—ROBERTS' LOOM. FRONT VIEW.

20), fixed upon the side of the lever, G, and pressing against the other lever, *d*, with which a click is connected. The degree of motion of the ratchet is regulated according

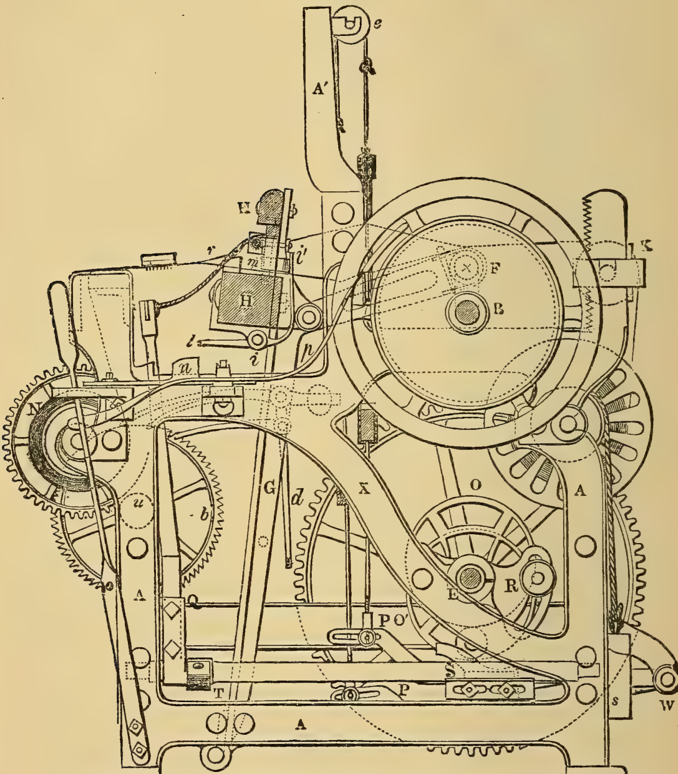


FIG. 20.—ROBERTS' LOOM. SECOND SIDE ELEVATION.

to the quality of the cloth, by fixing the click in different holes of the (dotted) lever, *d*. The lifting of the heddle, L, is performed by two eccentric tappets or wipers, O, O′,

upon the shaft, E, which press the treadle-levers, P, P′, alternately up and down. These levers are connected by strings or wires with their respective heddles, which are in their turn placed in communication by straps which play over the small rollers, *e*, *e*, at the top of the loom.

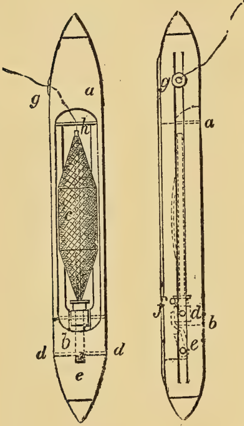
"In fig. 19, the levers, P, P′, have been shown in section, in order to explain the way in which the eccentrics, tappets, or cams work through the intervention of two small friction rollers, made fast to the levers.

"The shuttle is thrown by the two levers, Q, Q, which are alternately moved with a jerk of the rollers, R, fixed by arms on the shaft, E, and working upon cams, S, connected with the shafts of the arms, Q, Q. These arms, which represent the right arm of the hand-loom weaver, are united by the pecking-cord, T, which is mounted with a spring of spiral wire, so that either arm may be brought to its proper relative position.

"The shuttle is lodged in one of the boxes, *f*, *f*, of the batten, H, and is driven across along its shed-way by one of the pickers, *g*, *g*, which run on the two parallel guide-wires, *h*, *h*, and are connected with the peg-arms, Q, by strong cords. See fig. 19.

"If by any accident the shuttle should stick in the shed-way, the blows of the lay or batten, H, against it, would very soon cause the warp to be torn to pieces. In order to guard against this misfortune a contrivance has been introduced for stopping the loom immediately, in case the shuttle should not come home into its cell. Under the batten, H, fig. 20, there is a small shaft, *i*, figs. 18 and 18, on each side of which a lever, *l*, *l′*, fig. 18, is fixed. These two levers are pressed by springs against other levers, *m*, *m*, which enter partly into the shuttle-boxes. They act there as brakes to soften the impulse of the shuttle, and allow also the point of the lever, *l*, to fall downwards into a line with the prominence at *n*, provided the shuttles do not enter in and press the spring-point, *m*, backwards, and thereby the upright arm of the bent lever,

l′, onwards, so as to raise its horizontal arm, *l*, above *n*. When this does not take place, that is, when the shuttle has not gone fairly home, the lever, *l*, hangs down, strikes against the obstacle, *n*, moves this piece forwards, so as to press against the spring-lever or trigger, *o*, *o*, which leaps from its catch or detent, shifts the fork, *p*, *p*, with its strap, from the fast to the loose pulley at B, fig. 19, and thus, in a twinkling, arrests every motion of the machine. See figs. 18 and 20, at the right-hand sides.



FIGS. 21, 22.—ROBERTS' LOOM SHUTTLE; PLAN AND SIDE VIEWS.

"The shuttle is represented (fig. 21) in a top view, and fig. 22 in a side view. It is made of a piece of boxwood, excavated by a mortise in the middle, and tapered off at its ends, the lips being shod with iron points to protect them from injury by blows against the guides and the bottoms of the boxes.

"In the hollow part, *a*, *b*, there is a skewer or spindle, *c*, seen in dotted lines. One end of this skewer turns round about the axis, *d*, to allow it to come out of the mortise when the cop is to be put on.

"*e* (see the dotted lines in fig. 22 is the spring which keeps the spindle, *c*, in its place by pressing against one of the sides of the square ends of the spindle. *f* is a projecting pin or little stud, against which the spindle, *c*, bears, when laid in its place. *g* is a hole in one side of the shuttle, bushed with ivory, through which the thread passes, after being drawn through a slit in the centre of a brass plate, *h*. In that side of the shuttle which is furnished with the eye-hole, there is a groove extending its whole length for receiving the thread in its unwinding

from the cop. The under surface of the shuttle, which slides over the warp-shed, is made smooth from end to end by means of two wires, which abate the friction.

"Thus we see that in the power-loom there are eight points to be considered :—

1. The framework of the machine.
2. The mechanism connected with the warp.
3. The movement of the healds, or heddles.
4. The movement of the lathe, or batten.
5. The movement of the shuttle.
6. The mechanical arrangements of the whole machine.
7. The mode of action, or working of the several parts.
8. The methods of throwing the loom out of gear.

"1. The *framework* is of cast-iron, and is composed of two sides, each being cast in a single piece, marked A in the three figures, in which are seen an upright at each end, a cross-bar at top and bottom, with a curved bar diagonally placed. Upon the front of the uprights in fig. 19, immediately above the letter A, there are notched brackets for supporting the iron axes of the cloth beam, N. On the back uprights of the loom there is a slot-bar for supporting the axes of the warp-beam, I. See fig. 18. Towards the middle of the top rails of each side the vertical prolongation terminates in the arch A′.

"The cross binding-rails which unite the two faces and the two ends of the loom are,—

1. The great arched rail, A′, fig. 19, shaped like a basket-handle, which is made fast by screw-bolts and nuts, of which the heads are seen under A′ in fig. 18. This arc is destined to support the heddles, *e*, *e*.

2. The front cross-rail, A′, fig. 19, bifurcated at the ends to afford a greater extent of binding surface with the uprights.

3. The back cross-rail (not seen in these views), perfectly similar to the front one, A′.

"The frame-work is exceedingly substantial, and stands

steadily upon four large feet. The floor which bears it should be free from tremor; a stone or brick floor on the ground storey being the best.

2. *Arrangement of the Warp.*

"The warp is wound, as we have said, upon the cylindric wooden beam, I, figs. 18 and 20, from which it passes over the guide-friction roller, K, whereby it is brought into a horizontal plane suited to the play of the shuttle and the lathe. The cloth being formed at *r*, figs. 18 and 20, progressively slides over the strong breast-beam, M, and is wound upon the cloth-beam, N.

"It is essential to good work in the power-loom, that the warp and the cloth be uniformly stretched to the proper tension during the whole process of weaving; for if it become at any time greater, more force will be required to move the heddles in opening the shed, the yarns will get broken, and one shoot cannot be driven so close home upon another as when the tension is less. On the other hand, if the web be left too slack, the shoot of weft will be driven too far into the shed, and will thereby ride, in some measure, over the warp. It would not be difficult to give the chain the requisite degree of tension for the particular style of goods, were it not necessary to maintain it at the same pitch all the time that the cloth is winding, and the warp unwinding, about their respective rollers. The warp-beam, I, has at each of its ends a large wooden pulley (one is seen in fig. 18), which are fixed by screws upon the disc iron plate; round that pulley a cord makes two or more turns, and then hangs down with the tension weight at its end (see fig. 18); a light counter-weight, not seen in this view, hangs interiorly from the other end of the cord. The weight, *s*, consists of round plates of cast-iron, and it may, therefore, be modified at pleasure by increasing or diminishing their number.

"The roller, K, may be raised or lowered upon its rack-work upright, as shown in fig. 18.

"The surface of the breast-beam, M, slopes slightly, and is made very smooth to facilitate the sliding motion of the cloth in its way to be wound upon N.

"The cloth-roller, N, bears upon one of its iron axes prolonged, the toothed wheel, *a*, which works into a pinion (seen in dotted lines, *u*, in fig. 18) upon the axis of the ratchet-wheel, *b*. Hence if the ratchet-wheel be turned round, it will turn the pinion, *u*, and the wheel, *a*, on the shaft of the cylinder, N, so as to wind up the cloth as it is made. The click-lever on the top of the ratchet-wheel makes it hold whatever it has got, and thereby prevents the cloth from unrolling.

3. *Movement of the Heddles.*

"These are of the usual construction in this power-loom; they are shown in section at L, L′, fig. 20, and in front view in fig. 19. The loops or eyes, *v*, fig. 20, through which one-half of the threads of the warp passes, lie in two ranges; as also the loops, *v′*, of the other heddles, which transmit the other half of the threads. The loops are arranged in two ranks, and in different planes (on different levels), in order that the warp-yarns in passing may be brought closer together. Thus the even numbers of threads, 2, 6, 10, &c., which belong to the heddle L, pass in the loops of the first or upper range, and the numbers 4, 8, 12, &c., in those of the second range; and the odd numbers of threads, 1, 5, 9, &c., which belong to the treadle L′, pass in those of its upper range, and the numbers 3, 7, 11, &c., in those of the second.

"With the same view there are two heddle-sticks at L, L′, so that the threads which belong to the first range loops may be received over the two front rods above and below, and the threads which belong to the second range

may be received over the two back rods. In fig. 20 the line of division is shown in the middle of the section of the heddle-rods at L. The same takes place with the other heddle, L′.

"The rods of the first heddle-leaf are each attached above to two cords terminating in leather straps, *e*, *e* (fig. 19), the ends of which are nailed to the wooden pulleys, as shown in section at *e*, figs. 18 and 20. The rods of the second heddle-leaf are in like manner attached by two cords, with two leather straps nailed to similar pulleys. The last two pulleys have a smaller diameter than the first. Both systems of pulleys are fixed upon an iron shaft, which turns in the notch-bearings of the bracket projecting from the point, A′, of the basket-handle rail (as shown at *e*, fig. 18).

"At their under part, the heddle-leaves are also attached by two cords to two strong wooden bars, V, V, to the middle of which are fixed the iron rods, O, O, which are jointed to the treadle-marches, or steps, P, P′. These are connected by screw-joints (fig. 19), so that the point of attachment may be varied according to circumstances.

"We must now show how the treadles or marches, P, P (figs. 18 and 20), are raised and lowered, and how they effect, at the same time, the elevation or depression of the heddles.

"In figs. 18 and 20 are seen the two bent lever-bars, P, P′, which turn upon a fulcrum at W, and which are prevented from deviating sidewise by upright fixed bars, which pass through slits in their middle, as shown in fig. 20. When the march or lever, P, is pushed down, depressing the front heddles, the lever, P′, necessarily rises, because the one leather strap cannot roll round the pulley, *e*, without unrolling the other, and reciprocally. In order to shed the warp alternately, first in one direction and then in another, nothing is required but to depress, in succession, each of the treadles or levers, P, P′, taking care not to obstruct the motion of the rising one.

"The movements, 4, of the baton, and 5, which throws the shuttle, are essentially a little complicated, not so much from any difficulty of giving them the requisite velocity, as from the necessity of making them start precisely at an instant, dependent not merely on the position of the heddles, but on that also of the batten.

6, 7. *The Communication of Motion, or the Train of the Working Parts.*

"The driving-shaft, which puts the whole machine in motion, is represented by B, figs. 18 and 20. It is supported by the upper cross-rails, which extend beyond the side-frames, to carry upon the right hand the toothed wheel, D, fig. 20, and to the left the pulleys or outriggers, C, fig. 18, upon which the steam-belt runs. Inside of the frame, opposite each of the swords, G, of the batten, there is a crank mechanism, B, F, upon the driving-shaft, to which the links, F, *z*, are adjusted which move the batten. It is therefore evident that for every turn of the fly-wheel, C, or the steam pulley-shaft, the batten must make a complete vibration to and fro, advancing each time so as to beat up the shoot of weft at exactly the same point. Hence, if the main shaft make 120 revolutions in the minute, the shuttle must pass 120 times along the shuttle-rail.

"The toothed-wheel, D, figs. 19 and 20, making as many turns as the fly-wheel, works in the toothed-wheel, D′, of double diameter, and, therefore, communicates to it half its own velocity. This wheel, D′, is made fast to one of the extremities of the tappet, or wiper-shaft, E (figs. 18, 19, and 20), whose two bearings are in the curved diagonal rails, X, fig. 19. This shaft, E, is moreover supported in the middle by a clamp-collar, between O and O, fig. 19, in order to guard it against the least flexure, in consequence of the heavy strains it is exposed to in moving the treadles.

"The eccentrics, O, O′, are mounted upon the shaft, E, and, turning with it, impart alternate pressure to the marches or treadles, P, P, as well as to the pecking-arms, Q, Q′. The effect of these eccentrics may be readily conceived from their being of a spiral form, but with their curves placed in opposite positions. Hence, if from the common centre of the two eccentrics any radius be drawn to the two circumferences, the sum of the two portions of it, intercepted by the centre and each circumference, will be a constant quantity, which is the essential condition to be fulfilled by these eccentrics to give equal alternate impulsions.

"The ratio between the greater and smaller curvature of these eccentrics depends upon the extent of the opening or shedding of the warp for the shuttle-race. In the figures here engraved the measurements are $\frac{1}{4}$ and $\frac{1}{2}$ inch, which, by the scale of 1 inch to the foot, gives 3 inches and 6 inches; and as the bottoms of the upright rods which move the heddles work in the levers, P, at a great distance from the fulcrum, W, one-half greater than the eccentrics, O, or as the fraction $\frac{3}{2}$; the movement of the heddles will be $\frac{3}{2} \times 3$ inches $= 4\frac{1}{2}$ inches. In order to open the shed still more the lower ends of the heddle-rods would need merely to be removed by the slots and nuts farther from the fulcrum, W, that is, nearer to the points of the treadles, or tappet-wheels, O, O, of a greater eccentricity may be used.

"It is obvious that there should be a certain relation between the position of the crank elbows, B, F, figs. 18 and 20, and the position of the eccentrics, O. Thus, in figs. 18 and 19, the main shaft must make one-quarter of a turn before the crank, F, with its link, F y, can strike the batten, H, against the shoot of weft. During this quarter of a turn, the tappet-shaft, E, moving with one-half the speed, will make only one-eighth of a turn. The position of the eccentrics must be nicely adjusted upon their shafts to that of the crank, and firmly fixed in that position, so that the batten may strike home the shoot upon the closed

warp, or upon the warp still partly shed, as may be thought preferable. In the position shown by the figures, the lay will strike somewhat before the closing of the shed; for the eccentric or tappet-shaft, E, will make one-eighth of a turn, equivalent to one-quarter of a heddle-stroke, while the crank-shaft, B, will make the quarter of a revolution requisite to drive home the lay upon the shoot.

"We may now readily apprehend in what manner the double arm throws the shuttle at the proper moment. The two levers (figs. 18 and 19) which produce the pecking motion are actuated by two friction-rollers (one of which is seen to the right of R, fig. 18) attached to the eccentrics or tappets, and diametrically opposite the one to the other. By shifting the position of these projecting rollers in the curved slot of the eccentric, R, the throwing of the shuttle, effected by their striking down the pecking lever, may be adjusted to any point in the revolution of the tappet-shaft, which moves the heddles. As the shuttle can be thrown, however, only when the warp is open in a considerable degree, the screw-bolts which carry the wiper-rollers cannot be moved beyond the space included within the extremities of the great arcs of the eccentrics. And since there are two rollers diametrically opposite, it is obvious that in each complete revolution of the eccentrics the shuttle must be thrown twice; and as each of these revolutions corresponds to two revolutions of the crank-shaft, or two strokes of the batten, there will result, as there ought to do, one stroke of the battens for every passage of the shuttle.

"I have seen this power-loom weaving at very various speeds, from 100 pecks or shoots in the minute, up to 180. The average number in the most improved loom-shops for weaving calico may be reckoned 120.

"Near to each of its ends the warp-beam has two square-grooved large wooden pulleys, which are fixed by screws upon the cast-iron discs. These discs have a hollow

socket in their centres for receiving the ends of the beam; and they are also fixed by four screws, which pass down through this socket into the wood. To give them a firmer hold, the sockets have a projecting feather or wedge within, which fits into a square groove or mortise cut in the side of the roller. Round the smaller pulley a cord makes two turns, carrying upon its inner extremity a light weight, and upon its outer one a much heavier weight. Round the larger pulley, at the other end of the warp-beam, a similar tension-cord passes, but it makes four turns, bearing analogous weights to the former pulley. One of these weights is seen at *s* (figs. 18, 20).

"When the warp has been made fast, by securing its ends in the longitudinal groove of the beam, and by forcing the wedge-rule down upon the threads, and when it has been led over the guide-roller, K, and the breast-beam, M, and is tied in several little parcels to the cloth-beam, N, held by its ratchet-wheel, it will be stretched to a degree determined by the difference of the above pulley-weights.

"Let us recapitulate the train of its decussating operations, beginning at the moment when the shed is closed—that is, when the two heddle-leaves are at the same level, as well as the tappets of the treadles, which are now pressed by the intersecting points of the tappet-wheels. The batten is likewise at the limit of its advance, in the direction of the cloth, namely, striking home the shoot of weft. Supposing the loom to make 120 pecks in the minute, it will make, of course, a single peck in half a second; hence the fly-shaft makes a turn in half a second, and the tappet or eccentric-shaft makes a turn in a whole second. In moving from the above positions the tappet-wheels must make one-twelfth of a revolution in order to open the warp-shed completely, during which movement one-twelfth of a second will elapse; it remains open four-twelfths of a second, and takes again one-twelfth of a second to close, so that six-twelfths, or one-half, of a second elapse between the moment when the warp begins

to open, and the moment of its closing, while it remains completely open four-twelfths of a second.

"The shuttle is thrown at the moment when the tappet-roller at R strikes the bent lever at P beneath it, but the warp must be not merely opened for the shuttle to be thrown; the batten must be then at its utmost limit towards the heddles, in order to give the shuttle "ample room and verge enough." This is the condition which determines the place of the tappet-rollers upon the eccentrics. As the batten arrives near the heddles after three-twelfths of a second, it is obvious that the said roller should strike its lever a little before three-twelfths of a second have elapsed, or a little before the middle of the great arc of the eccentric; thus the shuttle starts before the batten has receded to its utmost limit towards the heddles, and it should have run through a little more than one-half of its race when the batten reaches that limit, so that it may arrive in time at the other end.

"When the shuttle completes its race, the batten has already passed the limit of its excursion towards the heddles, and is on its return to strike home the shoot of weft newly placed between the two portions of the opened warp. It has now its maximum velocity, because the cranks, B, F, are at nearly right angles to the links which move the swords, G, of the battens. This velocity diminishes in order that when the dents of the reed, borne along by the lay, come in contact with the weft to drive it home, they may act by gentle pressure rather than by a blow, so as not to injure the yarn. The warp being closed at the same instant, the pressure does not affect the loops of the heddles, but is exercised upon the warp and the cloth wholly in a longitudinal direction."

The foregoing description and illustration will clearly exhibit to the student the progress made in the construction and improvement of the power-loom in the interval between the time when the first inventor, Cartwright, laid down his task and the time when Roberts in relation to

this machine followed his example. We may now proceed to examine and describe the contributions of succeeding inventors, which have helped to make it the perfect automatic machine of to-day.

A company of inventors, Stanfield, Prichard, and Wilkinson, join in a patent for automatic stop motions, for stopping the loom on the breakage of the weft or warp-threads. These, however, need not be described, as neither of the principles embodied in their plans have come into use. In fact, no satisfactory and commercially successful method of stopping the loom on the breakage of a warp-thread has up to the time of this present writing been invented, though electricity amongst other agents has been tried.

The next great step in the improvement of the power-loom is one which does not appear to have been patented at all, so far as the writer can discover. This was the invention of the modern overpick-loom, probably best known as the Blackburn loom. Perhaps, to avoid all risk of confusion with the old overpick-loom, which, in an antiquated form, still survives in some of the woollen and worsted districts, it will be best to call this the horizontal side-pick. This well-known loom, which is now almost universal, was the invention of Mr. William Dickinson, of Blackburn, who at the time he worked out this great improvement was the manager for Messrs. Davison and Price, ironfounders and machinists, who then carried on business at the Eagle Foundry, Blackburn. This loom was, and still, of course, is, a very perfect mechanical reversion to the actions of the old hand-loom weaver, who threw his shuttle from hand to hand. The picking arrangement was very simple and efficient. It consisted of two tappet-bowls carried, one on a fixed arm at the end of the tappet-shaft, and the other attached to the arms of the spur-wheel upon the opposite end of the same shaft. The revolution of the shaft brought these bowls alternately sharply against two vertical levers attached to the loom-frame by, and pendant

from, pins on which they were pivoted. These levers were of a peculiar form, suited to yield the effect desired. To the bottom of each a leather band was attached, which extended to a sector on the bottom of a vertical shaft, to which it was attached. These shafts were fixed inside the loom-frame, about midway between the back and front, and carried upon their tops the picking-sticks horizontally extending over the shuttle-boxes. Connection with the pickers was established by picking-bands in the ordinary way. The two vertical shafts were also connected by a band called a "back-strap," really a check-strap, attached to small sectors on each shaft. In operation the bowls on the tappet-shaft in their revolution struck each picking-lever alternately, forcing them back from a vertical line and through the bands connecting them with the upright picking-shafts, sharply drawing the latter about one-third of a revolution round, causing the picking-stick upon its top to make a sharp movement, which, though describing an arc of a circle, gave a lateral movement to the picker, and thus projected the shuttle through the shed to the opposite box, whence, in the same manner, it was immediately returned. This is identically the same motion as that in vogue to-day. It will thus be seen that the picking-sticks, in this arrangement, very closely represent the arms of the olden time weaver, and simulate his action. This picking motion became very popular, and remained unchanged for about twenty-five years, when, about 1853, an improvement was effected in its details by the substitution of the cone-tappet, at present in use for the lever and bowl described above. This was also by Mr. William Dickinson, who had before this time founded the still existing firm of loom makers known as William Dickinson and Sons, Blackburn. Of this type of loom in its original and improved form, probably ten times as many have been made as of any other. Its details will come under notice subsequently.

Our review has now carried us to about the year 1830,

and it may be desirable to remark that the inventions to which references have been made are not more than one-tenth of the total number devoted to the improvement of the loom. The purpose of the writer has been, and will continue the same throughout, to notice only those improvements that have introduced principles, in however crude a form, that have maintained their position, and, with improvement in their details, have become integral and valuable portions of the loom of to-day, and with which there can be no thought of dispensing. It may be observed, however, that during the ten years from 1820 to 1830 there is visible an increasing effort to add two valuable features to the loom, namely, first, an automatic stop-motion, to stop the loom on the exhaustion or breakage of the weft; and second, an automatic, or self-acting temple. It is very curious to note with what persistency inventors went upon a false track in their endeavour to accomplish the former object. This was to devise an arrangement which, on the breakage of the thread, should prevent the shuttle entering the box to which it was proceeding. In the then existing arrangements of the loom this could only operate with disastrous effect upon the warp, which would be liable to be "smashed" every time the loom was thus stopped. Unquestionably the evils that would thus be produced would be greater than those endeavoured to be cured, and this, no doubt, was the reason that ultimately led to the abandonment of the attempt to solve the problem in this direction. In the matter of templing, the most various devices were resorted to, some of which, looked at in the light of present appliances, are exceedingly ludicrous.

Two other matters may, at this point, be referred to as greatly exercising the faculties of inventors. These were the taking-up and letting-off, or warp-pacing arrangements. As has already been shown, the true principles of these had been discovered and applied, but ill-considered attempts to improve upon or supersede them were numerous, and, as might be expected, quite futile.

In May, 1833, an American invention of a self-acting temple, an ingenious but complex device, was patented in this country, and appears to have met with a considerable amount of favour as being the most successful attempt to construct a self-acting temple that had been made. This is described and illustrated in Dr. Ure's "Cotton Manufacture," vol. ii. page 317, to which the curious reader is referred. Its principle is not one which could be approved.

In 1834 we find the record of an invention by Luke and John Smith of an improved picking arrangement, which has held its own to the present time. "Instead," say the patentees, "of operating upon the picking-levers, or picking-sticks, by gear or other mechanism heretofore employed, we fix upon the periphery of each fly-wheel certain inclined curvilinear projections which we denominate inclined planes, and each of these inclined planes is made to operate upon its respective picking-stick at every second revolution of the crank shaft." This is the old and well-known scroll-pick yet in use in heavy looms for cords, moles, ticking, and other heavy fabrics.

In May, 1834, two notable Blackburn names first appear in the inventors' list for improvements in looms. It would seem from the specification, and from a previous one of another inventor, that the taking-up roller was still used also as the roller on which to wind the cloth as it was woven. The consequence was, that as the cloth was wound upon it its diameter underwent enlargement, and its capacity for drawing down the warp correspondingly increased, the cloth gradually becoming thinner or receiving less picks as the weaving proceeded, which if permitted to continue would have resulted in a very great deterioration of the quality of the cloth at the end of the piece. Various plans were tried in order to obviate this result. One inventor borrowed the complex differential arrangement of the cone drums from the slubbing and roving frame, and the Blackburn inventors endeavoured

to solve the problem by the use of the disc arrangement for the same purpose. The ordinary method of overcoming the defect, and which perhaps was better than either of these, though troublesome, was to frequently change the pinion on the taking-up gear. It is strange that inventors should go to such trouble when the problem had been perfectly solved some time before by the introduction of a friction cloth roller, which was actuated by surface contact with the taking-up roller, thus winding on the cloth as it was woven without affecting the diameter of the taking-up roller at all. Reference is made to the Blackburn patent, however, more especially to note the first appearance of the "vibrating, or fly-reed," which was introduced in connection with a system of levers for stopping the loom on the breakage of the weft. Probably little conception was entertained at this time of the real importance of this loose reed, and of the great part it would afterwards play in developing the capacity of the loom. Though the Blackburn patent appears in the names of Messrs. Hornby and Kenworthy, the proprietor and the leading manager of Brookhouse Mills in that town, there is good reason to believe they were greatly assisted in devising their improvements by the celebrated inventor James Bullough, then in their employment, and whose own name first appears in the list of inventors the following year.

We now arrive at the date which marks another important invention, and which constituted a great step forward towards rendering the loom perfect. This was the simple and beautiful automatic weft stop-motion. This first appears in a specification granted to John Ramsbottom and Richard Holt, of Todmorden, July 12th, 1834, No. 6644. The specification mainly relates to an ingenious double vertical loom, an attempt to improve that of Thomas Johnson invented in 1807, the details of which it is not necessary to describe, as it did not take very long to demonstrate it could not succeed. A part of this invention consisted of the new automatic weft stopping motion just mentioned.

Though somewhat crude, the essence of the more perfect conception is there, and is very clearly defined. The contrivance consisted of levers, which the patentees call "hands and fingers." These were attached to rods extending across the loom and turning in bearings on the side standards. At each end of the reed there was an aperture in the shuttle-race, covered by some slight wires, set sufficiently apart to allow the fingers of the hands to pass through when not supported by the weft. To the rods were attached levers provided with notches, which levers were again connected to a sliding bar, so that when the fingers were not supported by the weft the notches on the levers were struck, and the levers and sliding-bar were raised by the lay, so as to allow a spring to act upon the driving-strap and traverse it from the fast to the loose pulley, at the same time bringing a nib on the sliding-bar in contact with a nib on the fly-wheel of the loom, which stopped it instantly. When the shuttle did not reach its box, a pendant lever was acted upon by a swell in the shuttle-box, so as to cause a catch upon it to come in contact with an arm extending from the sliding-bar, which was thereby raised and the loom stopped as before described.

On October 1st, 1835, James Bullough, of Blackburn, appeared in the Patent Office with an invention of a double horizontal loom having two beams, two slays, and two sets of healds, with the other necessary appendages. This was evidently suggested by the preceding invention, but was worked on different and better lines, and had all the merit of novelty. Included in this patent is an improved weft stopping motion and taking-up and letting-off arrangement. This specification affords another illustration of how clay and gold, so to speak, are mingled together, the double loom being radically wrong in principle when considered from an economical point of view. The only valuable points in this invention are those relating to the three automatic motions just mentioned.

In 1836 Andrew Parkinson patented "an improved stretcher, or temple," which consists of a circular disc, or wheel, the periphery of which is studded with pins. It is arranged horizontally near the edges of the cloth, and its revolution keeps the latter stretched to its proper width. This was a meritorious invention, and has not even yet been altogether discarded.

Though numerous inventions in connection with the loom continued to be made and patented, these related more to details or adjuncts than to the essential parts of the loom itself, and but little of a real advance was made in the next five years following the above-mentioned date.

In 1841 we come upon two important improvements embodied in one patent specification. These were, first, the trough and roller-temple, that in templing marked the introduction of a new principle, which, with improvements in details, has held its own ever since, and is probably, in connection with power-looms, the most universally used of all temples. The second of these was a great simplification and improvement in detail of the fork and grid weft stop motion, first introduced by Ramsbottom and Holt, as mentioned previously. The patent containing these improvements was granted to William Kenworthy and James Bullough, of Brookhouse, Blackburn, two names as well known as any in the roll of inventors in connection with the loom.

"This stop-motion," say the inventors, "consists in a very simple additional apparatus, which may be readily applied to looms in general, and may be termed the weft-watcher, or detector, as it points out with unerring certainty the breakage or absence of the weft-thread by the instantaneous disengagement of the taking-up motion, and entirely stopping the ordinary evolutions of the looms. As the object is to be accomplished by the absence of the weft-thread, we are enabled to give it sufficient strength or power, when in its place in the loom, to act

upon the throwing-off motion, by causing the thread to intersect a small forked lever which protrudes through the reed at every stroke of the slay or crossing of the weft, which will cause such forked lever to rise when the thread is present and to fall when absent, and thus to be placed in combination with another detector-lever, which is kept constantly vibrating or moving with the beating up of the slay, and by a proper arrangement and order of their motions will form an escapement, by which we are enabled to stop the taking-up motion and all other actions of the loom simultaneously merely by the absence of the very first pick of weft."

Here at last, fifty-five years after the invention of the power-loom, was an improvement which had been its chief desideratum from Cartwright's days. Without it the power-loom never could have entirely displaced the hand-loom, or have become the important machine it is to-day. As it was, before this improvement was effected, it required the closest and most unremitting attention of the weaver to prevent the warp being drawn down without its filling of weft, by which it was frayed and seriously injured. The cloth too was frequently damaged by "galls" and "cracks," or long and short spaces without weft. One loom was as much as many weavers could undertake the charge of, whilst the most skilful weaver of the time could not venture upon more than two, and these working at a speed of only about 120 to 130 picks per minute. This affords a great contrast to the picture presented to-day, in which it is a common practice for a weaver to take charge of from four to six looms, running from 220 to 260 picks per minute. This improvement rendered the loom an almost perfect automaton. As before observed, the first idea of this arrangement appears in the specification of Ramsbottom and Holt, of Todmorden. A second reference and description of the principle of this invention appears in a patent (a communication) granted to Moses Poole, November 12th, 1839, No. 8270. In the Abstracts

of Patents on Weaving, this is described as follows: "The ninth part of this invention relates to a method of stopping the loom when the weft is expended or broken. A "fork or grid," are placed at each side of the lay; the forks are connected by a rod which works in bearings. A curved lever is attached to the rod, which by coming in contact with a stud, or pin, causes the forks to be lifted out of the way of the shuttle as the lay goes back. When the weft is broken, the forks enter the grids, and actuate a balance lever, carrying a small projection, or knob, which comes directly in front of the stop-lever."

On the strength of this notice Clinton G. Gilroy claims to be the author of this invention. In a foot-note on page 416 of his well-known "History of the Art of Weaving," first published in New York, 1844, he makes the following statement:—

"This motion originated with us, in the beginning of the year 1831, at which period we applied it to a power-loom for weaving *Marseilles quilts;* and the patents obtained in England by Mr. Bullough and Mr. Ramsbottom, for modifications of it, of course, belong to us. We made still further improvements on the motion in the years 1836 and 1838, for which we obtained patents in November, 1839, in the name of Moses Poole, of the Patent Office, 4, Lincoln's Inn, Old Square, London. We also secured patents for the same invention in France and Belgium, through Harry Truffant, Esq., patent agent."

We regret, however, to say that in our opinion it would be injudicious to give unlimited credence to the claims of Clinton G. Gilroy, without obtaining therefor strong confirmatory evidence beyond that tendered in his book. In the above extract, his assertion that he "originated" this motion in the early part of 1831 is not supported by a tittle of evidence, whilst his own work affords evidence that he was a careful student of English patent specifications, and of the work of Dr. Ure on Cotton Manufacture, published in 1836, in which Ramsbottom and Holt's patent

is noticed. The improvements he asserts he made as above and patented in 1839, as will be observed from the description, scarcely carry the matter the smallest space beyond the point at which it was left by the Todmorden inventors, and it was far from attaining the simplicity and perfection reached by James Bullough in the invention of 1841.

The power-loom at this point of development had become in principle a perfect machine. The various motions necessary to form cloth: shedding of the warp, picking in the weft, driving it home, taking up the woven cloth, and giving out of the warp as needed, were all automatically performed, and, what is more, these movements were harmoniously combined and correlated, so that the result of their united action was a woven fabric produced without the intervention of human labour, at less cost and better in quality than that as a rule obtained from the work of the hand-loom weaver. It was thus not only a mechanical, but an economical success. In saying this, it is not meant to assert that it was perfect in its details: such was not the case; much ingenuity has since been expended in improving these during the last fifty years, and in order to bring it to its present stage of perfection.

A very brief glance only at a few of the most important inventions contributing to this result will be sufficient to give the student the necessary insight into its further advance and improvement, as they will all in their aggregate come under review subsequently.

The first invention of this kind calling for notice is that of the loose reed, by James Bullough, in 1842. This was practically the first of a series that has almost doubled the working capacity of the loom, enabling it to be run at a speed quite unattainable with the fast reed. In 1845, John Sellers, of Burnley, invented the first loom-brake, which became known as the "Burnley brake." This also was followed by a long series of improvements upon it by

various inventors, the effect of which has been to attain with it a degree of perfection that leaves little to be desired. In the same year a very useful little device, the continuous check-strap, was patented amongst a number of other small improvements, being included in a specification granted to William Eccles, William Crook, and William Lancaster, of Blackburn. The invention of the original check-strap, which probably was not continuous, is claimed for the late Mr. Robert Pickles, of Canton Mill, Burnley, who made it whilst an operative weaver between 1835 and 1840, the actual date being probably in the year 1838. The next improvement of importance was the introduction of the present method of picking by the cone and bowl in looms constructed on the Blackburn principle, or the modern over-pick, otherwise sometimes called the side-pick. This occurred about the year 1852, and, appropriately enough, originated in the establishment of the original inventor of this loom. Singularly enough, like the loom itself in the first instance, it does not appear to have been deemed of sufficient importance to be patented. At all events, no record is discoverable of either in the Abridgements of Specifications on Weaving. It was, however, found so superior to the older form of the lever-pick then in general use, that it quickly displaced it, being easily substituted.

Contemporaneously with the development of the power-loom, which in this chapter it has been endeavoured in its essential principles to trace, there were many hundreds of improvements in details, and many hundreds more of attempted improvements, but which in practice did not sustain the claims made on their account. These it has not been necessary to notice, though much that is curious and interesting to the technical student could have been found in them. Useful lessons might also have been deduced from them, as very often failures are more pregnant with instruction than instances of success.

CHAPTER IV.

WEAVING AND THE CONSTRUCTION OF WOVEN FABRICS.

The principles of weaving.—Its simplest form.—The variety of weaves.—Texture of plain cloth.—Healds and reed.—Weaving with one shaft of healds.—Ornamentation of plain cloth.—*The plain weave*, and its variations.—*The three-shaft twill;* designs and drafts.—*The four-shaft twill;* designs and drafts.—*The five-shaft twill;* designs, etc.—*The six-shaft twill;* designs, weave plans, and drafts.—*The seven-shaft twill;* designs and weave plans.—*The eight-shaft twill*, and variations.—*The nine-shaft twill.*—*The ten-shaft twill*, etc.—*Double and multiple cloth weaving;* description.—The fundamental principles of double-cloth weaving; numerous illustrations.—The laying out of fancy double cloths.—*Crimped cloths;* how to get the best effects; illustrations.—*Gauze or Leno weaving;* description.—Best expression of the gauze weave.—Light and elaborate effects.—*Cords, velvets, velveteens, plushes, moleskins;* descriptions and illustrations.—*Jacquard harness;* the London and Norwich ties.—The hooks of the jacquard machine.—Building the harness.—*Damask weaving;* the shedding capacity of the jacquard machine.—Designing for the jacquard.—Design or point paper.—Simplicity of jacquard drafts.—"Casting out" hooks and mails.—*The analysis or dissection of woven fabrics;* points to be noted, and method of procedure.

THE principles of an art may be called its foundation stones; and the natural consecutive developments from them the successive courses of the building contributing to the formation of the structure that, in its finished state, becomes a thing of utility, beauty, and a joy for ever. Some people may regard this as exaggerated language to apply to the somewhat homely and prosaic art of weaving, as they are accustomed to regard it. But such opinions, where they exist, may safely be attributed to an imperfectly developed capacity of observation, rather than to the absence or deficiency of beauty in the thing observed, when that is the art of weaving. The primary

object of the art is the provision of raiment for mankind, and for use in their dwellings. The fabrics devoted to these purposes may be plain, or be slightly or elaborately decorated. These, in their corresponding degree, call into requisition the simple, medium, or the most complex principles and mechanism of the art in order to produce the desired results. This chapter will, therefore, be devoted to an attempt to expound these principles, leaving the mechanism for subsequent review.

The writer has already, in a previous chapter, defined weaving as "the art of arranging, at right angles to each other, two or more series of threads of any suitable material, and binding them together by passing each thread under and over, and sometimes partially around, one another in regular alternation, or in such other order as may be needed to produce the required effect, by which arrangement they assume and retain an expanded form, rendering the fabric adaptable to many uses."

This definition might very properly be enlarged as not being sufficiently inclusive, as it does not bring in several classes of textile fabrics that can be made from a single thread. As instances of these we may point out knitted fabrics, nets, and point lace. Besides these, of which some people may doubt the appropriateness of the classification when brought within the category of textile fabrics, it is possible, and not only possible but a common practice to make fabrics in this manner from single threads. When in the production of these classes of fabrics the number of threads is increased, as they may be in knitting, netting, and the making of pillow lace, it is usually done to facilitate production, or to obtain a greater variety of results. As, however, it is not within the purpose of this work to give an exposition of these phases of the textile arts, but of the principles of weaving as ordinarily understood, they will not require more than a very slight reference.

In the interests of textile students, however, before leaving this point, we may observe that a properly woven

fabric as ordinarily understood, and including warp and weft, may be made from one single thread. As an experiment to prove this, let the student take a needle and a length of cotton thread, and, using it singly, pass it backward and forward, say through two pieces of paper kept an inch apart, for about twenty times, placing the thread at each passage alongside and parallel with the one put in before. This will give forty warp threads. Next turn the needle to the side of these, and pass it under and over each thread in succession until the needle passes out at the opposite side, drawing the thread close up. This done, reverse its direction, and alternate the interlacing until it emerges near where it first entered. Repeat this process until the thread in the needle is used up, or the warp threads are filled. In both cases take care that the threads are placed parallel and close together. It will then be seen that a perfect piece of cloth has thus been made, and if done skilfully it would not be easy for other than experts to say that it had not been produced by ordinary appliances. This is the irreducible simplicity of weaving, and as thus described is often used to effect repairs to fine linens and other fine fabrics in Germany, where the women are exceedingly skilful in such work. In England it is occasionally seen in the woollen districts, and in humble homes resort is had to it for mending hosiery, when it is familiarly known as "darning." With these observations on the elementary principle we may proceed to a more methodical exposition of the subject.

Weaving is the name given to the art of constructing textile fabrics. It is of the most simple, or the most elaborately complex character, according to the requirements of the articles sought to be made. The simplest form, as ordinarily understood and practised, requires the employment of two series of threads only. These are respectively termed the warp and the weft, or, as the latter is sometimes termed, the woof. The last name, however, is an archaic form of the word. The warp

consists of the longitudinal threads, or those which extend in the direction of its greatest length. The weft threads are the transverse ones, or those that pass under and over the warp threads from side to side. The warp threads may be of any length according to requirement or convenience; the requirement being that they shall not be less than is necessary to make the piece of cloth long enough for use for its intended purpose; and the convenience being that they shall not be longer than in the aggregate form of the warp can be conveniently handled or dealt with in the process of weaving. The minimum length of the weft threads is that required to go across the warp. In practice, however, they are always much longer, being formed into pirns, placed into shuttles as large as can conveniently be used, and so drawn off and left in the warp as the shuttle makes its rapid successive passages. Thus in the cotton trade each warp thread may be anywhere in length from 500 to 1,500 yards or even more; and each weft thread from 200 to 1,000 yards or more, according to the fineness of the counts being used, or the capacity of the shuttle to carry it.

If the almost countless methods and combinations of methods now in vogue in weaving be carefully analyzed they will be found capable of being reduced to a very small number of weaves. The following are the principal:—plain, twill, satin, spot, flush, cross-warp, and double-cloth textures. These each and all give their own simple results, and by combination they can be made to yield an almost infinite variety of complex ones. Simple and complex are alike obtained by the variations in the order by which the threads of the warp are lifted and depressed for the reception of the weft. This action is the shedding process, and correspondingly the means employed to produce the effects rise from the most simple to the elaborately complex shedding power of the modern Jacquard machine. The fact also ought to be noted here that this capacity for producing variety is enormously

increased when allied to the power given by the use of the system of multiple shuttle boxes of either the rising or revolving order.

The plain texture may be regarded as the foundation of all others, and therefore first calls for description. Let the student obtain and examine a piece of common calico, the coarser the better for his purpose, only taking care to obtain it of the full width. Examination will show it to consist of two series of threads, longitudinal and transverse ones. It will be observed that the warp threads lie parallel to each other in a common plane. The weft threads, it will be seen, intersect those of the warp, passing under and over them in alternating succession. Fig. 23 shows this construction plainly, the vertical threads, A, B, being warp threads, and the horizontal threads 1, 2 being weft threads. The detached portion of the figure at the top is a section, enlarged a little to show the construction clearly.

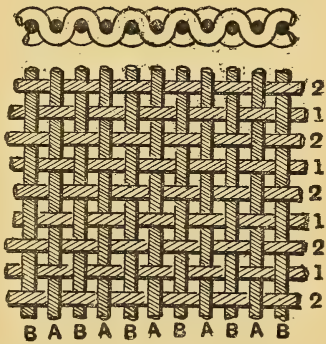


FIG. 23.

The student's sample will show the manner in which the weft threads are returned at the edges, the cloth making what is termed the selvage. In the actual process of construction the warp threads are maintained in a more or less tense condition, so that they are taken into the web of the cloth apparently in a straight line. But this is not actually so, as there is always more or less deflection into a more or less waved form, according to the thickness of the weft thread being inserted, and the degree of tension upon the warp. A similar deflection occurs in the weft threads, and when

the giving way in this respect is mutual and about equal, the two series of threads are bedded together in the best manner. At the option of the weaver, and according to requirement, this flexure may be thrown into either the warp or weft threads. In the section given in the figure it is shown in the weft threads.

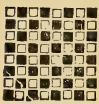


FIG. 24.

The design of this plain weave cloth, placed upon what is termed "point" or design paper, would appear very much like the squares of a chess-board. It is shown in fig. 24. Let it be assumed that the warp threads are white, and the weft threads black, and that the former run in a vertical direction, and the latter in a horizontal one. In the intersection of the threads which this represents the white squares show where a warp thread is uppermost, and the black squares where the weft

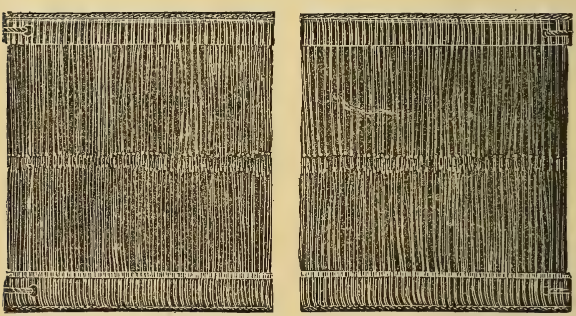


FIG. 25.—SHAFT OF HEALDS (BROKEN).

thread is on the top, and the warp thread down. The order of this alternation shows a plain weave, in silk weaving called a "tabby."

To obtain this result the weaver requires to have a certain control or command over the threads of the warp, in order to depress or elevate them in the manner re-

quired. This he gets in his shedding apparatus, the immediate instrument in this case being the heald, into which the warp threads are drawn.

The heald or heddle is composed of a cord formed of several strands of cotton, worsted, linen, or silk, but those used in the cotton trade are now in the main made of cotton, though still occasionally of worsted. A shaft of healds is shown in fig. 25, and a section of a set for weaving plain cloth in fig. 26. Healds are made upon a beautiful automatic machine exceedingly ingenious in construction, but space for a description here is not available. The eye in the centre, and through which the warp thread is drawn, is knitted into it when being made. The eye is formed of what is termed a mail, which may be made of steel, brass, or glass. The knitted eye is, however, the form in almost universal use in the cotton trade. These healds are mounted upon and stretched between two wooden laths, as shown in fig. 25, to the number of from 200 to 700, or more, according to the fineness or width of the cloth to be

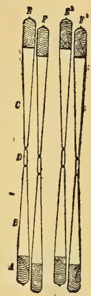


FIG. 26.

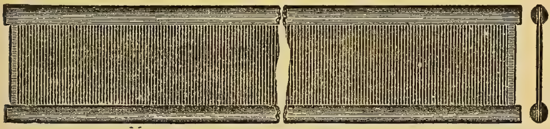


FIG. 27.—REED. SECTION.

woven. So mounted they form a leaf or shaft of healds or heddles, and a number of these, from two to ten, or even more, constitute a set of healds, the number of shafts varying according to the character of the weave intended to be employed. Two are all that are really required for a plain weave, but owing to the greater facility obtained in the way of condensing the warp, or

bringing its threads together, and minimizing friction upon the warp when being woven, four are generally used. Fig. 26 shows this arrangement. The two front leaves ascend and descend in the shedding together, and the two back ones in a similar manner alternate with them ; that is, when the front ones are up the back ones are down, and *vice versâ.* The draft or order in which the threads are entered into the healds is as follows, reckoning from the front or the shaft of healds nearest the reed of the loom, and commencing on the left-hand side of the healds :—the first thread is drawn in the heald on the first shaft, and the second thread upon one in the third shaft ; these two threads go together into the first dent or space in the reed ; the third thread is taken into the first heald on the second shaft, and the fourth thread into the first on the fourth shaft. This order is repeated and continued with the remaining portion of the warp until it is all drawn in. It is usual, however, in commencing the draft to draw two threads through each heald instead of one, for the first dozen healds or so, and to finish off in the same way. These double threads are called selvage threads, properly self-edge threads, and are purposely made stronger by doubling to resist the drag of the weft upon them, as it is returned into the shed. Sometimes the two outer threads are made threefold, and again, in very good fabrics, special selvage threads are introduced of twofold twisted yarns.

At this point it will be appropriate to describe in a very brief manner the reed, the ever-present adjunct of the healds. It is so named from having been originally composed of split reeds, the vegetable product of that name. It is now made of iron or brass, but mostly of the former. Wire of the required gauge is rolled and flattened to proper dimensions, highly polished, and run on a reel. It is then transferred to a reed-making machine, another of the wonderfully ingenious machines, adjuncts of the textile trades. The reed machine is furnished with the parts of the reed termed the reed back, composed of two strips of

wood each for the top and the bottom. The machine is also supplied with two reels of pitch twine. Being set in operation, a strong or terminal dent is first put in, when the machine begins to cut the flattened wire into short lengths, and to place them successively in position with their ends between the two pairs of strips forming the backs. When one of these short lengths, or dents, as they are called, has been pushed forward, it is immediately secured in position by the machine wrapping a turn of the pitch-band close up to it around the two strips. Another strip is then advanced and the operation repeated, and so on until the reed is made of the required length. It is then finished off with another strong and broad dent. Fig. 27 gives an illustration of a front view and section. The more openly these dents are set in the reed the coarser or lower are its counts; and the closer they are the finer it becomes. This is all that is necessary to state in this place regarding it. The remainder will be more properly told in another section.

Before leaving this point, we may observe that since writing the above, the author has been informed by a textile expert that, in his young days, when on a visit to Ireland, he saw the rough frieze being woven with a single shaft of healds. This is a fact that will be interesting to the student, as it singularly and most remarkably confirms the theoretic elucidation of the progress of invention in the art of weaving given in Chapter I., pages 26 and 27. It would be highly interesting to learn whether this primitive method is still anywhere followed in Ireland.

It must not be assumed that ornamentation cannot be put into a plain weave cloth. There are several methods of effecting this. The first is by making what are called tape stripes parallel with its length. These are made by drawing-in the warp in double threads similar to the manner of the selvage threads, and doing this according to any given design. Many fabrics are made in this way, though not so many now as was once the case. Some-

times the effect is obtained by the use of two counts of yarn in the warp, fine and coarse, the latter to form the tape. Another variation can be introduced by using two counts of wefts and a two-shuttle loom. In this case a cord weft is introduced for a few picks at regular distances, making a stripe across the cloth. The first-described are termed "stripes," really parallel stripes; the latter are called "cross-over stripes," to distinguish them from those parallel. A further variation is obtained by the employment of these two methods in combination. This produces a class of fabrics termed "tape-checks." A great variety of these can be made, and formerly they were a very popular fabric. Another line of variation is obtained by the introduction of cords, as seen in the familiar instance of handkerchief borders.

It will be obvious that many other combinations and variations in ornamentation can be made by the introduction of coloured yarns in the warp and in the weft and in both. These need not be further enlarged upon, as an almost endless number will suggest themselves. The whole class of ginghams are types belonging to this division.

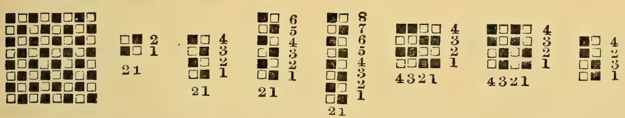
The Plain Weave.

A more technical exposition of the various weaves may now follow: the plain weave naturally comes first. Let the reader bear in mind that all the black squares in the design and weave plans given in this weave and its variations show weft intersections in which the weft rides upon the top of the warp threads; and that the blank or white squares indicate that the warp in that position is uppermost, and the weft below. If the weft did not interlace with the warp in this manner all would be blanks and the formation of a woven fabric impossible.

Fig. 28 gives the design as already explained. This consists of two warp and two weft threads crossing each

other at right angles. In coarse, open cloths, such as canvas, etc., two heald shafts would be sufficient. The draft or weave plan, which means the order in which the warp is drawn into the healds, would then be represented in A. The numbers on the right-hand side indicate the draft of the warp threads through the healds on the shafts in the order of their arrangement; and the figures at the bottom show the order of the weft picks. As explained before, where a great number of warp threads require to be dealt with, and concentration is necessary, as in fine cotton, worsted, and silk fabrics, four, six, or eight heald shafts are introduced in order to secure a better distribution of the warp threads, thus diminishing the crowding, reducing

FIG. 28. A. B. C. D. E. F. G.



PLAIN CLOTH, WITH THE DESIGN, WEAVE PLANS, AND VARIATIONS.

the friction, and lessening the breakages of the threads that would otherwise occur in the weaving of closely compacted fabrics. In these cases the drafts B, C, and D would represent respectively the use of sets of healds of four, six, and eight shafts, and the order of warp drafts for them. In such drafts the shedding is easier as the threads pass each other with less friction, and both yarn and healds are opened more easily to take up broken threads when these occur.

Whilst two, four, six, or eight shafts are commonly used for plain cloth, any even number will give the same result, providing the warp threads are drafted in consecutive order, and the odd numbers of the shafts can be lifted together for one shed, and the even numbers together for the alternate one.

Some observations have already been made upon the

methods of ornamenting plain cloths, and a few more may be permitted, as it is quite a mistake to suppose that the plain weave is incapable of yielding ornamentation. It has been shown how tape stripes and checks, both in plain and coloured goods, can be produced. These will yield some very effective patterns for muslins and light zephyrs, whilst mock gauzes, in which a series of reed dents are left without warp threads, form another interesting class in plain weave fabrics, the beauty of which can be further enhanced by the introduction of coloured yarn.

The draft E shews a warp cord, and the draft F a weft cord or rep. The thickness of the cord in the warp may be carried to any extent by increasing the number of threads that form it, or it may be obtained by introducing a second warp of coarse yarn. The weft cord, or rep, by introducing catch cords at the selvages may have any number of picks put into one shed, and these can be bound down by one or more picks in the alternate shed. Of course in the power-loom this implies the introduction of an intermittent shedding arrangement. As in the warp cord so in the weft, coarse and fine counts may alternate to give the effect. By a combination of warp and weft cords squares of basket figures or checks can be produced in endless variety, which make not only useful but beautiful fabrics. A plain weave also forms a secure basis or ground for Jacquard figures.

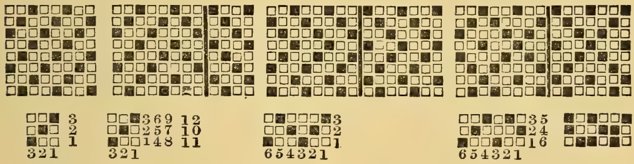
In the interweaving of coarse and fine yarns of warp and weft it is necessary to exercise judgment and care in proportioning the quantities, and particularly in cord effects.

Calicoes and nearly all ordinary plain cloths are woven with what is technically called a skip-shaft draft. This is shown in the draft G, which has been explained before. The four heald shafts rise and fall as if they were two only as will be seen on a glance at the marginal figures.

The Three-Shaft Twill.

The three-shaft twill next comes under notice. This weave is known by many names, such as drill, regatta, Jean, Jeanette, Llama, etc. It is the first departure from the plain weave and is the simplest weave after it. It is worked, as its name indicates, by three shafts of healds which work independently of one another, rising and falling in regular sequence in the order of their arrangement from the front, 1, 2, 3, 1, 2, 3, in continuous repetitions. Its effect is to throw up distinct ridges of weft that run diagonally across the cloth, ascending from left to right. This is caused by the weft always passing under

FIG. 29. FIG. 30. FIG. 31. FIG. 32.



A. B. C. D. E.

THE 3-SHAFT TWILL, WITH DESIGNS, DRAFTS, ETC.

two warp threads and then over the next, as shown in the design (fig. 29) and its draft, A. It would appear from a casual glance at the design that it would not admit of much variation. It is, however, capable of considerable ornamentation, as is shown by the succeeding designs (figs. 30, 31, 32). Their respective drafts accompany them. In fig. 32 an alternative draft is given. A very bold twill figure, the diagonal rib, can be obtained by the employment of heavy yarns, and a fine effect by the use of fine yarns and closely set reeds. This twill is extensively used for light fancy lining cloths, and it generally forms a base for thicksets, velveteens, cords, and heavy fabrics. As a simple form

of decoration, without colour, it is one of the most useful weaves in the whole list for diaper, herring-bone styles, and other goods. When employed in the woollen trade it is sometimes called the prunella twill, and it is known in the Bradford worsted trade as the Llama twill. By introducing coloured yarns and arranging them one and one, say black, blue, and white, the diagonal stripes may be crossed and form a series of checks or hair lines, giving a result that cannot be obtained from any other twill weave. In design, fig. 30, is shown an alternated reversal of the weave, forming what is called a herring-bone twill, from its supposed resemblance to the backbone of that fish. The next design (fig. 31) shows a transverse herring-bone; that is, the former design is made to have its line of direction across the cloth instead of, as before, along its length. Design fig. 32 is a diaper, its plan and draft being given in D. Weave plan E is that of a double twill, by which distinct colours can be obtained on each side of the fabric; for instance, with a white warp and a brown weft the warp would be thrown up, giving the fabric a white face, whilst the weft being thrown down would give a brown back. This may be regarded as a mock double cloth in which the backing is weft.

The examples given will show that this weave may be made a very useful one in the weaving-shed if a little judgment be exercised in its application and in the selection of suitable materials and colours. With these aids a great number of excellent effects may be obtained from this apparently comparatively inflexible weave.

In extensive designs of floral treatment, or other figures, this twill forms a good firm ground as a binder of either warp or weft threads.

In plain cloths it was stated that the yarns used in making them gave the best effects when the twine or twist was in the same direction, because yarns thus constructed imbed themselves better in each other, and so produce a more level and closely compacted cloth, which is the

object sought. In twills, on the contrary, the development of the figure is a principal object sought, therefore the angle of direction of the twill should be in opposition, and not coincidence, to that of the yarns used in order to prevent the bedding effect of the alternate course, and so help to develop a clear and bold effect in the line of the twill.

The Four-Shaft Twill.

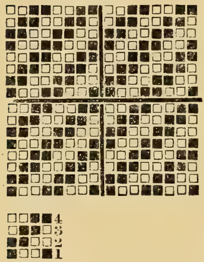
The next step brings before us the four-shaft twill. It must be borne in mind that every step forward made by the addition of another leaf of healds gives increasing capacity of figure production to the weaver, enabling the weaver, to borrow a metaphor from the church belfry, to ring an additional number of changes upon his instrument, the loom.

The four-shaft twill is variously known as the cassimere, kerseymere, serge, blanket, florentine, swansdown, crow, etc. It is in almost universal use in the weaving world, entering more or less into the composition of fabrics of every known textile fibre. It can be adapted to any counts of yarn and produce satisfactory results. In the fustian trade it is extensively used for plain-backed Genoa velvets, velverets, thickset cords, and an endless variety of patterns for suitings, trouserings, etc., in woollens, worsteds, fine hair lines, warp face figures, etc. It is impossible to enumerate in any reasonable space all the changes that can be made by the weave and draft of a four-shaft twill either alone or in combination with other weaves. The examples given herewith will, however, serve to point out to the student a portion of its capabilities, and indicate the lines upon which he may develop others for himself. The first design shown (fig. 33) is the ordinary disposition of this twill as seen in its common use. It is accompanied by its weave plan and draft, A, as usual. In the next (fig. 34) is shown the herring-bone or ticking

stripe, a design much used in making bed-ticking and pillow-case fabrics. The draft is shown at B, the weave being the same as A.

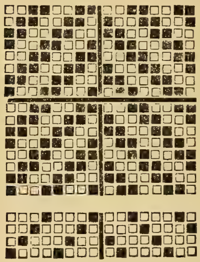
The next design (fig. 35) shows a check formation which may be extended to any size by repeated drafts and

Fig. 33.



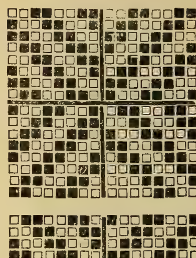
A.

Fig. 34.



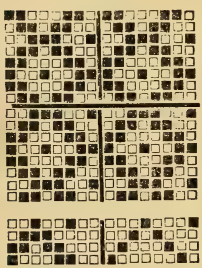
B.

Fig. 35.



C.

Fig. 36.



D. D1.

Fig. 37.

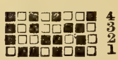
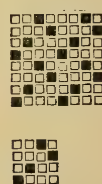


Fig. 38.



E.

The 4-Shaft Twill: Designs, Weave Plans, and Drafts.

threads. The weave plan appears in C, whilst the draft is a repeat of B, fig. 34. Many beautiful effects can be produced by this weave and method of drafting.

The following design (fig. 36) is one for a diaper cloth, and its weave plan and draft are shown in D and D′.

The next design (fig. 37) is that of a double twill. In

this the face may be made very fine, and the back be weighted with much coarser material. It is mostly used in cotton quiltings and mixed goods of cotton warp and woollen wefts. The amount of material put into the fabric will, to a certain extent, govern the application of the rule previously laid down regarding the direction of the twist of the yarns used. Where the warp is used in the production of the face cloth, the same regard to the direction of the twist is not imperative ; it is when the warp and weft are equally balanced in counts that the observance of the rule becomes important.

In design fig. 38 the satin twill is delineated with its accompanying weave E. This form of twill though not perfect, is used for the bulk of cloths having the greatest portion of either their warp or weft brought to the surface.

The Five-Shaft Twill.

The five-shaft twill is the next on the roll. This is used for heavy fabrics, such as drills, sateens, doeskins, damasks, etc. In fancy diaper cloths it affords great scope for the production of varieties. It is the first perfect satin twill, and it yields many derivatives. Satin twills give a peculiar angle when formed by warp threads. They yield greater strength in the lengthway of the fabric than most other weaves of this type. The reader must here be guarded against the possible confusion that may arise between the terms satin and sateen. The former is the weave employed in making the silk fabric termed satin, in which the weave effect is obtained by throwing the warp to the surface, thus showing the threads running parallel with the length of the fabric; in the sateen weave the weft is thrown to the surface, and the line of the visible threads upon it runs across the cloth from side to side. When the sateen or weft twill is used, the satin or warp twill is simply thrown to the back of the fabric, and *vice*

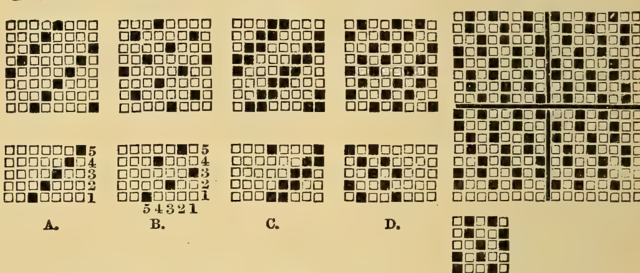
versâ. This principle governs both of these weaves whenever they are employed.

In the design fig. 39 is given the ordinary weave of the five-shaft twill; A shows its weave plan and draft.

In design fig. 40 the satin weave is given, and in B its plan and draft.

In design fig. 41 a fancy twill is given, and in C its weave is shown. As will be seen by referring to A (fig. 39) there is merely an additional black square introduced and placed below each of those in the original plan. This

Fig. 39. Fig. 40. Fig. 41. Fig. 42. Fig. 43.



The 5-Shaft Twill Design, Etc.

makes two each in the run where there was only one before. An excellent effect is obtained from it.

The design shown in fig. 42 will give a very firm weave, in which there will be no risk of the threads of the fabric slipping. It is very suitable for linings. Its plan appears in D.

Design fig. 43 is derived from that shown in fig. 40, and is obtained by the introduction of another dot for each of those in the former design. Its plan is shown at E.

All the drafts in these examples are straight-over drafts. Numerous other weaves might be brought forward to show the wide range of usefulness of this twill, but those given are their foundations and the ones from which they are derived. The combinations that can be

made of these yield many interesting results, and the exercise of developing them would be most useful to the student.

As a ground for figured effects the five-shaft twill is much used by designers for all kinds of silk, cotton, linen, woollen and worsted goods.

The Six-Shaft Twill.

This is deservedly a favourite basis for almost every class of fabric, and with colours in warp and weft will give numerous combinations.

In design fig. 44 is given the basic arrangement of the weave, showing equal flushing of warp and weft. The weave plan, A, it will be seen from the figures on the margin, is a straight-over draft.

Design fig. 45 is also a form of twill very frequently seen; in this there are more warp threads brought to the surface. The weave plan, B, shows it to be a straight draft.

The next design (fig. 46) divides the diagonal figure into two portions, bringing a warp thread up between the floating weft threads. In this design, instead of floating three and sinking three, they float two, sink one and float one. This arrangement increases the firmness of the fabric from that of fig. 44, but sacrifices some capacity for a display of colours. The weave plan is C, a straight draft.

In design fig. 47 is given a variation, suitable and in use for diaper patterns. In the weave plan, D, the draft is shown by the figures at the margin.

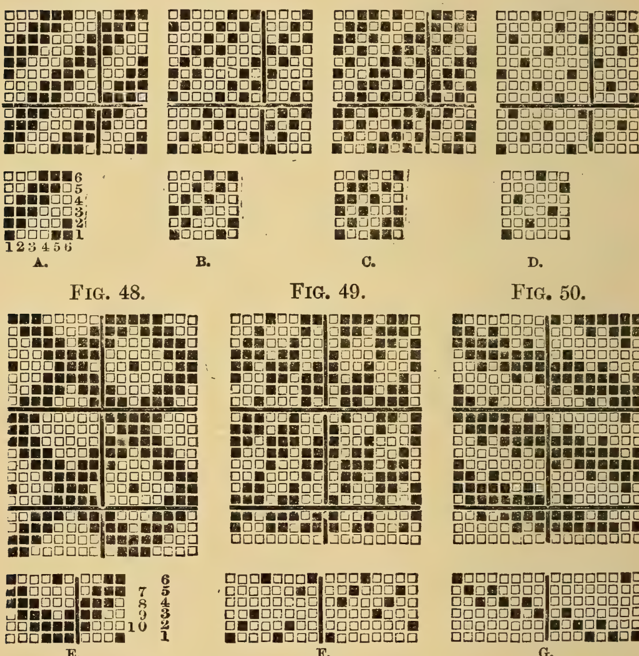
Design fig. 48 exhibits a satin as made on six shafts. The weave, E, shows it a straight draft. This is termed one of the imperfect satins, though largely used as a ground for figured effects.

There are numerous derivatives from all regular twills,

producing the effect of several portions of a twill combined in one weave. The six-shaft twill under notice affords numerous examples, one of which, with the explanation of its formation will suffice to show how others can be con-

Fig. 44. Fig. 45. Fig. 46. Fig. 47.

Fig. 48. Fig. 49. Fig. 50.



THE 6-SHAFT TWILL: DESIGNS, WEAVE PLANS, AND DRAFTS.

structed. For this weave plan A (fig. 44) may be taken as a foundation. The number for counting off determines the number of threads to be used in each part before changing. The number to be left out shows the number of threads to be skipped, and also gives the number of the thread on which the next change will take place.

As an illustration, design fig. 49 is given. The number of threads used in this are three for each change, whilst two threads are left for each skip. By referring to the figures given at the bottom of the weave plan, A (fig. 44), the arrangement of the threads in the design can be easily followed by observing this rule. The full repeat is shown, F being the draft.

Design fig. 50 is another form of construction, G being the weave plan. In these drafts the warp threads are evenly distributed over the shafts, no shaft being overloaded. From a weaver's point of view, this is a great advantage in weaving many fabrics composed of fine, tender yarns. The number of threads used for a change may be increased, as, for instance, a design may be constructed from the weave plan, A (fig. 44), by counting six and skipping two. In fact, the capability of changing is almost inexhaustible, and offers a fine field for study to the textile student. In every twill, whatever may be the number of shafts, this system can be utilized with the most satisfactory results. These remarks will obviate the necessity of going over the same ground again in other examples to be brought forward. They will also be found sufficient to convey the necessary practical information for developing new ideas and obtaining fresh and useful weaves.

The Seven-Shaft Twill.

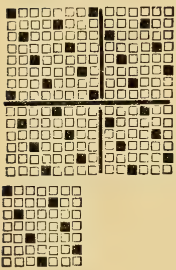
The seven-shaft twill, which we now proceed to notice, conducts the student another step forward in the path in which he obtains increased capacity. The first design given (fig. 51) is a satin, A being the weave plan. This is a perfect satin, as we may observe, in passing, are all satins that are formed by an odd number of threads in the straight-over draft, or in the number required to form a complete pattern. There are many rules given for the placing of the wefts dots or intersections in a satin weave,

but the simplest method is the best. This is to take the first number after one that is not a measure of the shafts or repeat threads. Thus three would be the first number in seven after one, therefore this may be used to count with as follows:

$$\dot{1},\ \dot{6},\ \dot{4},\ \dot{2},\ \dot{7},\ \dot{5},\ \dot{3}.$$

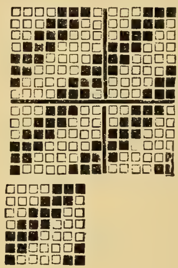
The dots represent the seven shafts or threads. This gives one plan of intersections by the use of three as a measure. But four may be used also as it is not a

FIG. 51.



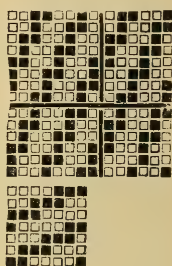
A.

FIG. 52.



B.

FIG. 53.



C.

THE 7-SHAFT TWILL: DESIGNS AND WEAVE PLANS.

multiple of seven, and this would give the following arrangement:

$$\dot{1},\ \dot{3},\ \dot{5},\ \dot{7},\ \dot{2},\ \dot{4},\ \dot{6}.$$

Upon this principle the intersecting dots of any satin may be found; and on reference to design fig. 51 it will be seen how these latter figures have been practically applied.

Design fig. 52 is a regular seven-shaft twill, with its accompanying weave plan, B, a straight draft.

Design fig. 53 is a derivative twill with a more vertical

figure, obtained from the satin arrangement of fig. 51. Its weave plan is given in C.

The remarks made about the six-shaft twill apply with equal force to this and all other twills, so that there is no need to increase the number of examples, as, by following the instructions given, any number can be constructed with facility, whilst by combinations with other twills, reverse drafts, and colours, the capacity for obtaining variation of effect will be found to have hardly any limit.

The Eight-Shaft Twill.

The eight-shaft twill is again richer in its effects and variations than the preceding. In design fig. 54 is given the ordinary eight-shaft twill, straight draft and weave plan, A.

Design fig. 55 is a fancy broken twill, formed from the weave plan, A, fig. 54. The draft is given in B, and the extended weave plan in C. This example will prove a good study for the student, because a further fresh disposition of the draft would bring out another formation equally useful and ornamental.

Design fig. 56 is a diaper arrangement constructed from the V draft D, its weave plan being given in E. It will now be quite obvious that any other eight-shaft weave with the same draft would give further novelties.

Design fig. 57 is a satin with its weave, F, the draft being straight over.

Design fig. 58 is a combination on eight shafts of design fig. 54 and its satin arrangement, which will give a stripe effect. Naturally it will be evident that the width of the stripe can be increased by an extension of the draft given at G. The weave plan is the same as A of design fig. 54.

It would be quite impossible to give any adequate conception of the number of changes that can be brought out

FIG. 54.

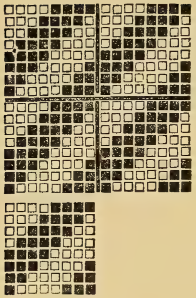


FIG. 55.

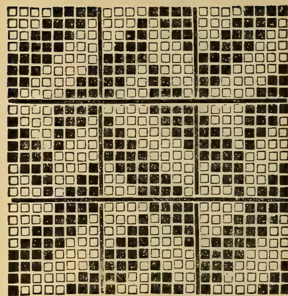
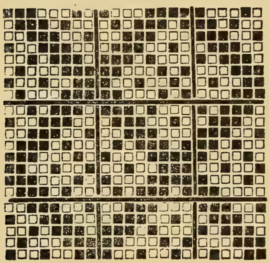
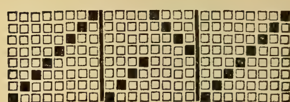
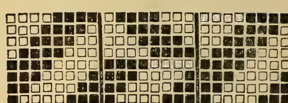


FIG. 56.



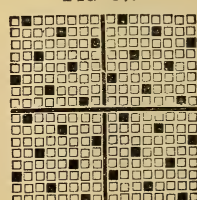


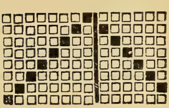
B.



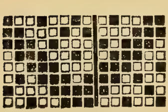
C.

FIG 57.

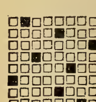




D.



E.

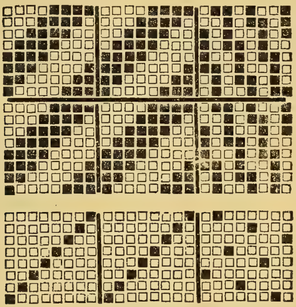


F

THE 8-SHAFT TWILL AND VARIATIONS.

from the drafts, etc., but the examples given will serve to represent the main features. As foundation weaves they will produce highly desirable results when wrought in well-chosen materials.

FIG. 58.



G.

THE 8-SHAFT TWILL *(continued)*.

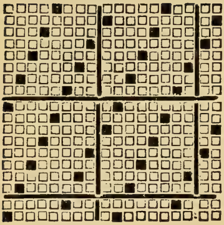
The Nine-Shaft Twill.

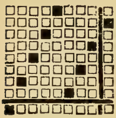
The first design given here (fig. 59), is for a satin twill, the weave plan being given in A; straight draft.

Design fig. 60 is one of the many forms used for fancy weaves in either stripes, checks, or colours. Its weave plan, B; straight draft.

Design fig. 61 is a broken form of the twill, giving novel effects. The draft is shown at C. This, to the technical student, is an instructive and suggestive design, as though, in reality, there are only nine threads, yet by the use of the weave plan, D, their skilful distribution gives in the design shown twenty-seven threads to the round or full figure. This figure may be re-arranged by the alteration of the draft. Care, however, requires to be taken to compose the draft in such a manner that, as

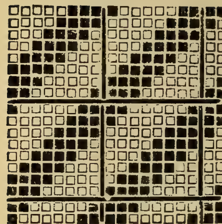
Fig. 59.

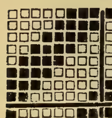




A.

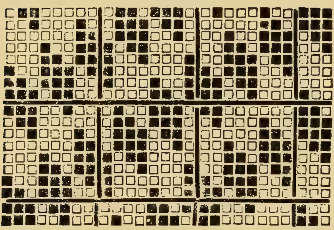
Fig. 60.

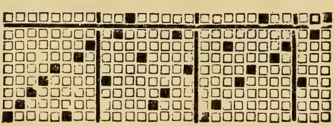




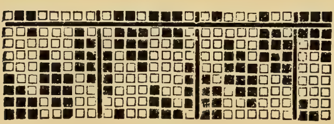
B.

Fig. 61.





C.



D.

The 9-Shaft Twill, etc.

in D, the shafts shall carry an equal number of threads, namely, $9 \times 3 = 27$. This gives three repeats of the nine threads to one figure of the fancy pattern. This required care observed, a perfect joining of the pattern will be made.

From designs such as are here given any number of patterns can be obtained by a slight study of the draft and weave arrangements, the essential point for consideration being to make them neat, chaste, and beautiful, so that when wrought into suitable kinds of fabrics, they may prove of high commercial value.

The Ten-Shaft Twill.

This is the last of this series proposed to be given, as it may be fairly assumed that their fundamental principles will then have been fully treated.

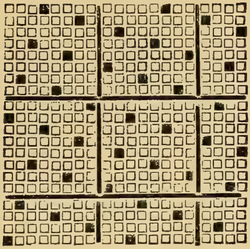
The first design (fig. 62) is a ten-shaft satin, with its weave plan, A; straight draft. If sateens are required to be made on any number of shafts, all that is necessary is to bring the back of the satin cloth to the face; that is, to work one shaft up successively all through the series, and the others down.

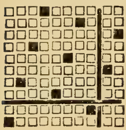
In design fig. 63, which is for a fancy fabric, the figure is of the diagonal type, having combined with it a Vandyke border; B is the weave plan; straight draft.

From fig. 63 is derived the next design (fig. 64) with the B weave plan, and the same straight draft. In this way it yields a broken-up effect, very useful in woollen and kindred fabrics, or where type effects of a similar character are required.

In the next design (fig. 65) an extension is made in order to show the joinings of the figures; C is the draft, and D the weave plan. By doubling or tripling this form of draft, a very complicated series of figures could be obtained that would appear as if woven with a Jacquard machine.

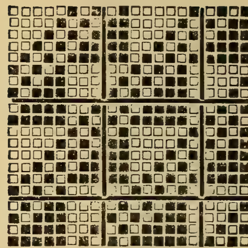
Fig. 62.

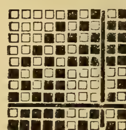




A.

Fig. 63.





B.

Fig. 64.

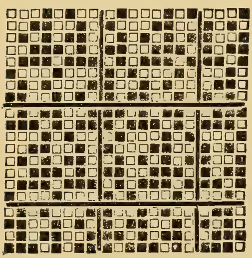
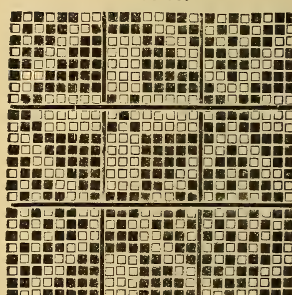
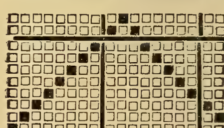
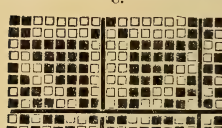


Fig. 65.





C.



D.

The 10-Shaft Twill, etc.

The exigencies of space preclude any further exposition of this phase of the subject. That already given constitutes a sufficient guide for the development and treatment of all designs capable of being made upon any shedding mechanism or apparatus in use, with the exception of the Jacquard machine, which requires a special description. The changes capable of being developed and wrought by the adaptations and combinations of the weaves and drafts already given are almost infinite, and if executed with knowledge, skill, and taste will prove of considerable monetary value.

In larger designs, such as damask figures, the satin weaves act as binders; or the ground may be warp satin, and the figures weft or sateen twills. In these classes of goods two colours are generally used, unless they are fabrics intended for bleaching. One colour is used for the warp, and another for the weft. The ground is preferentially obtained by a weft effect, as the figures stand out more boldly when constructed of a warp satin. Hence all the threads composing the figure effects will have the twill running lengthwise of the cloth, whilst the ground twill, composed of the weft, will run across.

Throughout the preceding remarks, it has been endeavoured to expound the principles of the various weaves and their combinations from a practical standpoint, in order that no difficulty might be encountered by the student in at once making a practical application of them.

Double and Multiple Cloth Weaving.

The student of the textile arts who is only familiar with the plain calico weaving which is so extensive in the cotton, will learn, perhaps with surprise, that double cloths are commonly made in some districts, and that triple cloths are occasionally made, whilst manifold cloths can be made in very ordinary looms with some little extra

adjuncts. In order that the student may in some degree be equipped for and prepared to meet all requirements that may be made upon him, some description of these modes of procedure may now be given.

A true double cloth is really two cloths woven at one operation in the same loom. They may, when removed from the loom, be perfectly separate, or combined at one or both sides, or may adhere to one another more or less closely by connecting threads, or be so closely interwoven with each other in that manner that only persons with some technical knowledge really could know the true nature of the fabric. The two cloths may differ in pattern, in fineness of material, and even be of materials quite different from one another in their origin, mode of construction, and the weave by which they are put together. Two, three, or even more pieces of cloth of the width of the loom might be woven together, and being united at the sides when taken from the loom would open out into one wide sheet, three or four times the width of the loom in which it had been produced. Or two widths might be made together and joined at each side, when the fabric would be a cylindrical tube if opened out. In weaving this it might be interwoven at given distances as required, and being cut across at these, the cut lengths would form seamless bags. Many millions of these, popularly called "mutton bags," are made in Lancashire for the Australian and New Zealand frozen meat trade, each bag being of sufficient dimensions to receive the carcase of a sheep.

When double cloths are made reversible they have either two warp or weft faces. When extra weight is required, as in most woollen fabrics, and in some cotton ones, as quiltings, a backing of coarser material, either in the warp or weft, may be attached to the face cloth by what are termed stitching threads, which may be more or less in number, according to the degree of attachment required. In many cases fabrics are thus made three and

even fourfold, not only for obtaining a fine face, strength, warmth, or weight at a low cost, but for getting strange effects and fancy figures by making the cloths interchangeable. Of course when double cloths are produced the maker is endeavouring to meet some distinct requirement, and it is in this way that tubular fabrics, hose pipes and sacks have been produced.

The fundamental principles of these peculiar weaves are simply and clearly stated, and may be easily understood by an examination of the following weaves, in which the dots represent that the heald shaft, and consequently the warp thread is uppermost. The figures at the foot of the weaves show the picks of weft, and those at the side the order of drawing-in the warp threads on the heald shafts. With a warp in two colours, and a pattern two white and two blue threads, the white portion of the warp would be on the first and second shafts, and the blue on the third and fourth shafts. If this pattern was woven with one shuttle, and with the skip-shaft draft of the plain weave given at the opening of these weave expositions, in which the first and third threads would be taken for the first shed, and the second and fourth for the alternate shed, only a single cloth would be formed having a stripe pattern. But by the use of two shuttles, one containing white and the other blue weft, with the weave shown in fig. 66, two separate cloths would be obtained, one all white and the other all blue. The explanation of this is as follows :—On the first pick with the blue shuttle a shed is formed for its passage by the whole of the white warp being lifted above the shuttle-race, and one-half of the blue warp as well. The blue pick taken through the shed by the shuttle gives one-half of the blue cloth ; on the return passage of the blue shuttle in the next shed the blue cloth is completed, without mixture with the white warp, because the whole of the white warp is still kept up, whilst the second half of the blue warp has been lifted, and the first half sent down, as will be seen by the

blank square on the second pick of the figure. In the next movement the white shuttle comes into work. The third pick is now made, all the blue and one-half of the white warp being sunk, whilst the shuttle makes its passage, the other half of the white warp being kept up to form the shed. This pick of the white weft gives one-half of the white fabric, and when the white sheds have changed their positions, and the return pick of the white shuttle is made, the white fabric will be completed, and two separate cloths, one blue and one white, will have been formed.

If one shuttle only had been used with the above weave the cloths would have been united at the selvages, and a tubular fabric would have been made. It is in this manner hose-pipe, lamp-wick, tucks, bags, etc., are formed. By the addition of a second set of four-heald shafts, making eight shafts in all, and having each coloured warp upon one distinct set, squares for vestings, fancy dress goods, bed-spreads, etc., can easily be developed. All that is necessary is to enlarge upon the weave (fig. 66) just given. Though in the last illustration two shafts were allotted to the blue warp and two to the white warp, there is no reason why ten shafts, or any other number, should not be used for one warp and an equal number for the other, or three, four, or six sets might be used for as many coloured warps and wefts. The principle would be the same, and these are merely adduced to partially show its capacity of application. The different sizes of squares depend upon the number of repeats of each colour over its own set of shafts, and the corresponding number of treads of the warp and passage of the same coloured shuttle until the square is completed. This done, another set of shafts having another coloured warp with its corresponding coloured shuttle is brought into operation.

The weave given in fig. 67 is one for two colours, blue and white, or any other two, warped end and end and drawn in as shown by the marginal figures; the draft on

each set of shafts being repeated to the extent necessary to get the required dimensions, and the treads of each section picked over for a corresponding number of times of blue and white shuttles, alternate squares of blue and white double cloth will be formed.

Fig. 68 gives a double twill cloth, the weft twill being

FIG. 66.

FIG. 67.

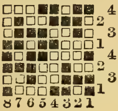


FIG. 68.

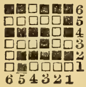


FIG. 69.

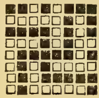


FIG. 70.

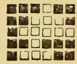


FIG. 71.

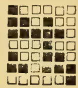


FIG. 72.

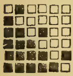


FIG. 73.

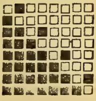


FIG. 74.

FIG. 75.

FIG. 76.

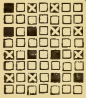


FIG. 77.

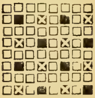


FIG. 78.

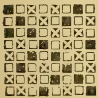


FIG. 79.

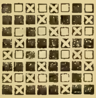


FIG. 80.

FIG. 81.

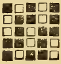


FIG. 82.

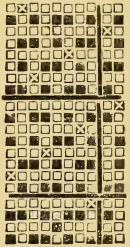
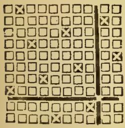


FIG. 83.



DOUBLE CLOTHS: WEAVES, ETC.

inside the cylinder cloth that it forms. The figures on the margin show the draft, and those at the bottom the threads. This is the three-shaft twill.

The next design (fig. 69) is the four-shaft twill double cloth. The weave given in fig. 68 is also used for this when employed for bags and tubular fabrics.

The next (fig. 70) is a weave that will produce three

cloths in a loom of, say, thirty inches wide, that when woven and opened out will be ninety inches wide, or three times the width of the loom. We commend it to the attention of young students.

If the next weave (fig. 71) had a warp of three colours, warped thread and thread of each in alternation, say brown, blue, and cream, the weft to be picked one pick of each colour in succession, then three fabrics each of a distinct colour would be produced.

Fig. 72 is the same as the last with the variation of requiring only that two threads of each colour shall go together and two picks of each coloured weft be used to correspond. This does away with the necessity of using the pick-and-pick loom as three boxes on one side would do the work.

The next (fig. 73) worked on this principle will give four pieces of plain cloth, each two shafts producing a separate piece of cloth. This system may be carried to any extent, but its principal value lies in the fact that, by the introduction of a stitching thread, the whole four fabrics may be made of any thickness and be bound into one solid cloth. Such cloths if made in woollen might be felted, and of course would contain three or four times the quantity of material as the case might be.

To attempt the exposition of the principles in the fullest detail, and to give minute particulars of the constructions of double cloth fabrics, would require a volume for the task, and which, it will be obvious, cannot be given. A few examples of the system adopted in ordinary practice for backing cloths must suffice.

For backing a twill face such as is given in fig. 74, a suitable backing would be that shown in fig. 75. The first step is the face (fig. 76), and fig. 77 shows the back; fig. 78 gives face and back cloths combined; fig. 79 shows the face warp up to admit the back pick, and fig. 80 the back warp down to admit the face pick.

In these several figures a complete analysis of the

method of backing a cloth is given, and it illustrates the principle upon which all such fabrics with a twill face are constructed. The crosses in the design show the position of the stitching or back points all through. A close study of these figures will thoroughly reveal the operation. The point to be determined is whether the stitch is to be obtained from a plain or satin weave. The method of obtaining the intersecting points of any satin weave has already been given, and the rule can be applied to double cloths. But the face weave, of whatever kind it may be, must always govern the back weave, because the face weave may have to be repeated in such a manner as to make it a measure for the back weave. If the flushing of the weft is somewhat long, the stitching must be got as near to the centre of the float, or flush, as possible, and with the face pick going immediately before and immediately following it. To illustrate these remarks fig. 81 is given, which is a five-shaft twill; and fig. 82 shows the repeat, so that it may be stitched with a ten-shaft satin plan. An examination of the two figures will show that the stitching is equally distributed, the face pick preceding and following the stitcher. The principle of the matter is in the count which the backing or satin weave must give. In figs. 82 and 83 it will be seen that two is the count, beginning from the left-hand side, and this counting follows the angle of the twill.

The best practice in laying out for fancy double cloths is to design the face twill or figure separately, and should it require a warp back the vertical spaces in the design are left vacant if the backing is one of face and one of back threads; if two face threads to one of back, then the design would be for the face weave two vertical rows dotted, and one row blank, and so on in this order through the design. If a weft back is required, then the transverse rows are left vacant according to the disposition of the weft picks. After duly considering a face cloth design, a suitable backing weave is drawn out on separate design paper.

This gives a complete idea of the upper and lower surfaces of the cloth, and the backing weave is then run in on the vacant spaces left in the face design. It may, and does often, occur that many designs are so peculiar that it is difficult to devise a proper backing weave for them. In these cases an irregular satin twill will often be found useful. It is of no moment how irregular the stitches may be if they do not show on the face cloth. Judgment must, of course, be exercised to prevent such blemishes. If the illustrations herewith given are carefully studied, they will be found to afford a sufficient exposition of the principles involved in the construction of double cloths, and the practice of them will make an expert.

Crimped Cloths.

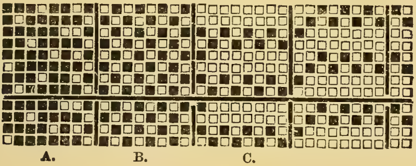
In fancy woven goods a crimped effect can often be introduced with great advantage to embellish the fabric. It contrasts very effectively with any other weave with which it may be combined, and gives ornamental results that cannot otherwise be obtained. At the time of writing this (1893), and for some while past, it has been highly popular as a component part of fancy woven fabrics.

In order to get the best effects, it is necessary to carefully consider the various combinations forming the fabric. A certain relationship that is unchanging, and that gives the maximum of beautiful effect, always exists between the different weaves when used in combination, and it is for the textile artist to discover and employ this in preference to the other dispositions not so good. The chief point to be regarded is the careful handling of the plain weave upon which the crimped effect is to be placed. The portion of the warp to be devoted to crimping, must be run upon a separate beam, for the reception of which provision must be made in the loom. This beam, which we may term the crimp beam, must be very lightly

weighted compared with the other, in order to permit the slay, when beating up the weft pick, to draw the warp from the crimp beam into horizontal ridges, as it is woven. The warp upon the other beam must be kept in a state of tight or high tension, as this is required, and also gives a better contrasting effect.

Fig. 84 shows a combination weave of satin, plain, and cord. As far as designing any weave is concerned, it is comparatively simple. Ribs of different widths may be constructed, and various arrangements of colours adopted at will. The greater the number of weft picks put in, the

FIG. 84.



CRIMPED CLOTH.

better will be the result. Fancy twills, or figure developments, may take the place of plain stripes.

In fig. 84, A shows a six-shaft satin stripe face effect; B the plain or crimped stripe; and C the corded stripe. Any number of ends may be drawn on each set of shafts, but it is advisable not to unduly extend the width of the various stripes, but to keep them in a proper proportion to each other.

The principle of the construction of these cloths is here pointed out, and all that is required further for the production of very saleable and popular fabrics is taste and judgment.

Cords, Velvets, Velveteens, Plushes, Moleskins, etc.

The term velvet, though properly belonging to a silken fabric, is now also generally applied to fine cotton fabrics

made in imitation thereof. The pile of silk velvet is made from the warp, that of all cotton imitations from the weft. To be correctly described, the latter should be termed cotton velvets, to distinguish them from the heavier makes of the same class of cloths which are usually termed velveteens. Silk velvets are always made by the insertion of wires into the shed of the warp, either by the hand of the weaver or by automatic mechanism. In many cases these wires are formed into a knife-blade at one end, so that as they are withdrawn from the other they cut the pile; in other cases the plain wire is used, and the pile cut afterwards. Worsted velvets and plushes are formed in the same manner. Cotton velvets, velveteens, and other cotton-pile fabrics, are made differently, the pile always being formed by the weft, and for this the wire is not applicable. After these goods are woven the pieces are subjected to another process, that of pile-cutting, in which, either by hand or machine, the pile is cut in a direction parallel with the length of the fabric, in this respect also differing from the silk fabric, where the cutting is in the direction of its width. Dressing, dyeing, finishing, and making-up complete the goods for the market.

In the classes of cotton fabrics named above there are numerous varieties, but the examples given below are selected from the best in general use to-day, and will serve the requirements of illustration at present, which is simply to show their principles of construction, and that they belong to the division of double cloths.

Our first illustration (fig. 85) is of a tabby or plain-backed velvet; it is made on six shafts, with a straight draft, and eight picks to the round.

Our next (fig. 86) is a weave variation for velveteen, made on six shafts, and with nine picks to the round.

The third (fig. 87) is also a velveteen made on six shafts, with twelve picks to the round.

Fig. 88 represents a very popular class of velveteens, made on six shafts, with twelve picks to the round, con-

FIG. 85.

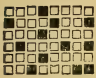


FIG. 86.

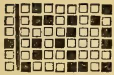


FIG. 87.

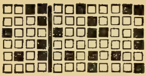


FIG. 88.

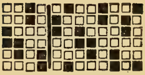


FIG. 89.

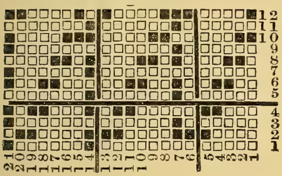


FIG. 90.

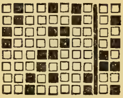


FIG. 91.

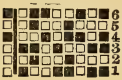


FIG. 92.

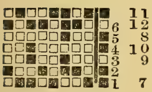


FIG. 93.

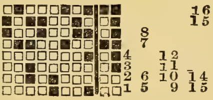


FIG. 94.

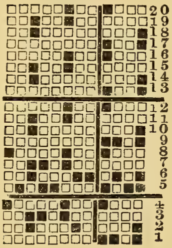


FIG. 95.

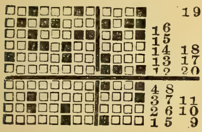
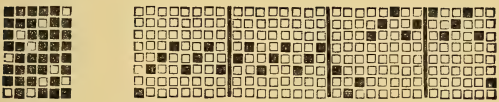
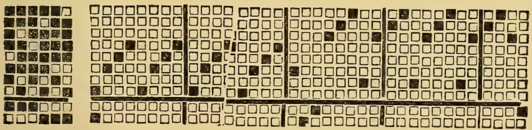


FIG. 96.



A: DRAFT.

FIG. 97



B: DRAFT.

VELVETS, VELVETEENS, CORDS, AND PLUSHES.

taining 1,860 threads in 30 inches of width, equal to 62 warp threads in 1 inch. The warp yarn is 16^s or 18^s, the weft counts and number of picks according to requirement, this being generally a given weight per yard.

The next (fig. 89) is a velvet with a jean back. The weave shows how the pile and the stitching threads are put in, which will convey a good idea of the construction of this class of fabrics. The twelve shafts on which it is made are numbered on the margin of the plan ; the treads or weft picks at the bottom from 1 to 21. The pile or weft face is formed by six picks and the stitching thread, binder, or back, as it is indifferently termed, is the seventh tread or pick ; then follows another six picks for pile, which brings us to the fourteenth, forming the second stitching or binder pick tying the face and back together ; and, lastly follows six more pile picks and one more stitching pick, completing the round of twenty-one picks. Thus, it will be seen, eighteen pile picks are used, with three jean twill picks for binder and back, which gives a proper and proportionate construction. The ordinary four-shaft kerseymere twill could be used for the back, but if six picks of pile weft were put between each pick of the twill back, twenty-eight picks to the round would be required, as in all backed cloths ; whatever may be the weaves used for the back and face they must work in harmony with each other throughout the round, or the result will be imperfect.

Fig. 90 exhibits a ribbed velveteen, made on eight shafts, straight draft and ten picks to the round. This requires good yarns, uniformly cylindrical, to make a neat fabric, because the rib is formed from them.

Coming to the cords, which constitute another class of heavy cotton goods, kindred to the latter, the first specimen is given in the design of a thickset-cord (fig. 91), the least in size that can be constructed. The pile forms two separate cords, and in the cutting process the cutter runs his knife between the threads Nos. 2 and 5 (see the

numbers on the margin of the design, fig. 91). In the construction of the fabric a tube or longitudinal cell is formed to admit of the cutting process, and to separate the pile into the lines which form the peculiar feature of cords. The back of this example is constructed in the same manner as a velveteen, being composed of two single jean twills. The best reed in which to make it would be a 36^s Stockport count, and a 14^s single warp, with sufficient weft picks to give a weight of 10 ozs. per yard.

Fig. 92 is a seven-shaft cord, the draft of which is given in figures on the margin.

Fig. 93 is a double jean round top cord, eight shafts, sixteen ends draft, and ten picks to the round.

Fig. 94 is the analysis of a cable cord on twenty warp threads.

Fig. 95 is the reduction to ten shafts, draft on the margin; twelve picks to the round.

Fig. 96, with the draft A, will produce the hunter's cord. It is made on eight shafts, with a thirty end draft, which is given in A, and six picks to the round. With this design and draft fancy cords with stripes of various colours can be made with the greatest facility. With twenty-four dents per inch in the reed, 16^s warp, three threads in a dent, and sixty picks per inch of 14^s weft, an excellent fabric will be obtained.

In fig. 97 a variation of the hunter's cord is given, known as the "Bedford." This is often produced in woollen and worsted. It differs in its construction from the modern ladies' dress-cloth which has usurped its name. It is made on ten shafts, with a thirty-six end draft, given in B, and six picks to the round. Good useful cloths are made in it by using a 30^s reed, with three, five, and six threads per dent, and 29 inches wide.

A great variety of weft and warp cords might be brought forward, but the principal having been given they will suffice for the purpose, as it is not difficult to produce others by changes of material, weaves, and drafting.

Plush is a pile fabric having a longer pile than velvet or velveteen It is of two kinds, warp and weft plush. The former is made by the same means as silk velvet, cut-pile carpets, etc. The pile is formed by the insertion of wires, and cut by their withdrawal. The loop plushes, of which the familiar Brussels carpet is a type, are made in the same way, but the pile is not cut, as the wires are not armed with knives. Weft plush is made by merely extending the length of the pile of velvets and velveteens. It is made by the same weaves. The ground may be either plain or twilled. When woven it is cut in the same manner as velvets and cords, and dyed and finished as they are.

In making these goods it is best to use the sateen dis-

FIG. 98.

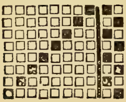
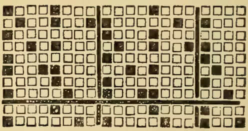


FIG. 99.



VELVETS, VELVETEENS, CORDS, AND PLUSHES (*continued*).

tribution of the stitching or binding threads, as regular courses are thus ensured for the cutter's knives. Fig. 98 gives a plush on eight shafts with a straight draft, two weft picks, plain weave for binders to form the back, and eight plush picks.

Fig. 99 is one on ten shafts, straight draft, and twenty picks to the round, five of which are used to form the twill back.

For seal or other imitation skins, fancy coloured mottled yarns are used, and, if necessary, a greater number of shafts with more extended drafts are brought into use, but the principles of construction are the same throughout, and this being the case further examples need not be given.

Gauze or Leno Fabrics.

We now come to the exposition of a weave which differs in its principle from any that have gone before, and constitutes the fabrics into which it is introduced, a class by themselves. In all the preceding weaves, however intricate the patterns are or may be made, one principle underlies them all ; the warp and weft threads are arranged in their respective parallel orders, and more or less close together, according to the required density or openness of the fabric to be constructed. This order is also maintained in gauze or leno weaving, two names which are indifferently used to designate the same thing. The point of difference arises in the manner in which the intersections of the threads are made. Instead of the intersections being, as before, between the warp and weft threads, they are made entirely between the warp threads themselves, and bound in position by the weft threads. This is shown in the following illustration (fig. 100). There are two warp threads, A, B, and four weft threads shown. Let the student take the thread A, and examine its relationship to the weft. It will be found that it passes under every one of the four threads of weft. Now take the thread B, follow its course in the same way, and it will be found that it passes over every one of the four threads of weft. In all ordinary weaves with such an arrangement of warp and weft threads, there being no intersections between the two series of threads, there would be no fabric. The intersections, however, have been removed from the weft and transferred to the warp, and take place amongst the warp threads themselves, and only amongst them. It will be observed that the warp threads

FIG. 100.

cross one another in the spaces from right to left, and left to right alternately. But even here they are not like the intersections of the ordinary weave: in making these crossings they never go under and over each other, as do the threads of warp under and over the threads of weft. They simply cross one another from side to side, the same threads being always uppermost and always undermost throughout their respective courses. It will be obvious that mere crossings of this kind could never make an arrangement of threads that would be permanent, which is an essential requirement in the construction of a woven fabric. Steps must therefore be taken to render these crossings of the warp threads permanent. This is accomplished by the introduction of the weft threads in the manner shown. In the shedding arrangement the white thread, A, is so actuated that it is depressed first on the right of the black thread, B, and then on the left of it, so much as to allow the weft threads, 1, 2, 3, 4, etc., always to pass over it. Correspondingly, the black thread, B, is always raised to let the weft threads pass under it, it thus coming to pass that the white thread is always down and the black thread always up in their final disposition. The function of the weft, it will thus be seen, is to form a binder or retaining thread, in order to keep the warp threads permanently in the position they have been made to assume. This passage of the warp threads across and partially around each other, is ordinarily described as a twisting movement, but this is not correct. The twist or twine is mostly imperfect, as only in a few special cases in the loom do the threads make a passage around each other of more than three-quarters of a revolution, from which point they reverse their movement, returning on the track they came to the point whence they started. In the lace machine or loom the revolution is complete, but it is made by the weft passing completely around a warp thread, instead of the partial twist of two warp threads.

The method of constructing gauze weaves differs con-

siderably from that of ordinary weaves, because of certain conditions governing the twisting of the warp threads. A design for gauze is therefore more difficult to comprehend, and before attempting to construct one, it will be desirable to briefly examine the mechanical devices for crossing the warp threads. Without the acquisition of this knowledge as a preliminary, it would be wasted time investigating the construction of gauze fabrics.

In weaving gauze fabrics, or seeking to introduce gauze effects amongst other weaves, two sets of heald shafts are required. The first set, called the plain shafts, *a*, is to produce the ordinary weave that may be required, and to co-operate with the gauze or second set, which are termed the gauze healds. The second set, for the crossing or twisting operation, carry the "doup" healds, *b*. Sometimes these are made with the doup shaft at the top and sometimes at the bottom; both these methods are shown in fig. 101. They have what weavers term a double eye, or an eye or opening for receiving the warp thread below the centre of the heald, and a second one immediately above. This set of healds or doups in working are always subject to a far larger amount of friction than the ordinary healds, and therefore require to be made of material that will successfully resist the great friction to which they are subject. This should be silk, or a strong and highly finished cord that has surfaces that will permit the warp threads to glide against them with a minimum of friction, and consequently of wear and tear. The two sets of shafts are, however, connected with each other by their healds, and therefore are actually arranged in pairs. Fig. 101 gives a good illustration of the construction of the doup heald. The loop, *e*, formed by the cord, passes through the eye of

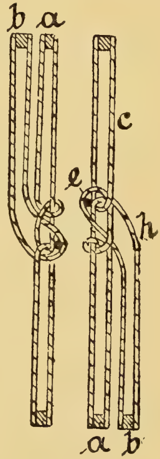


FIG. 101.

the standard heald and carries a warp thread. This it transfers, in alternation, first to one side and then the other of its companion thread in the "standard" heald which holds the doup heald. This doup, with its thread, is the chief factor in gauze weaving. The doup cord is shown at *h*, and *c* is the standard heald.

In draughting or drawing in the warp, in cases where doup healds are employed, the first warp thread is drawn in the first shaft of the standard healds, as usual in plain cloth weaving, and then through its doup, whilst the next is drawn through the second standard shaft directly over the doup thread just described, both threads entering one

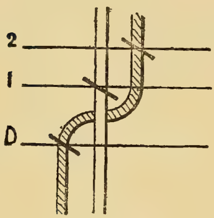


FIG. 102.

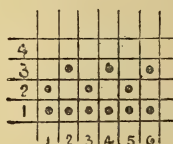


FIG. 103.

dent of the reed. And so the draft proceeds in this order across the warp. When the draft is decided upon, the drawing-in follows it as given.

In fig. 102, which is the pegging plan, D is the doup, and figs. 1, 2, the plain weave shafts. Fig. 104 shows the first thread on the first shaft, and the second thread on the second shaft, and so continued over the two shafts. In this figure the doup thread is shown at A, and, as will be observed, is passed under the threads with which it will work, and through the loop of the doup heald. The thread B is only drawn in on the regular shaft, and passes through the gauze shaft between the doup healds, without being subjected to them in any way. An examination will show that the doup thread A, in the plain

healds, is on the left of B; in the gauze healds it is on the right of B. When the threads are thus arranged, their action is always conjoined, and they are dented, or drawn through the reed into the same space together.

In fig. 103 the weave plan for an ordinary gauze is shown on design paper. Two of the vertical lines constitute a representation of fig. 102, but the representation has been extended to three repeats, in order to show its appearance more fully upon paper.

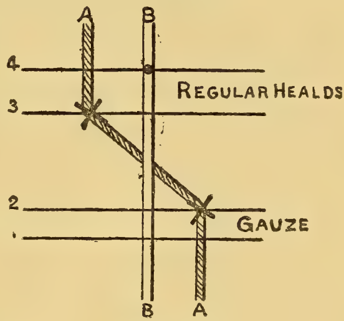


FIG. 104.

To give proper expression to the character of the gauze weave, it must have a contrasting plain or satin weave beside it in stripes, when it will stand out clearly and distinctly, forming a fine lace-like ornamentation. If it is desired to carry the ornamentation further, the fabric can be

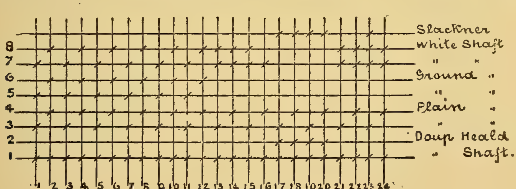


FIG. 105.

checked by a plain transverse stripe, in which case the weave must be of the same texture as the plain weave in longitudinal or plain warp stripe. The doup or whip-thread, or the ground, is double when gauze is made, but the plain weave separates them. Fig. 105 is the weave plan, numbered from 1 to 8. In this plan No. 1 gives the

action of the doup shaft, which is raised at every weft pick; No. 2 is the doup heald, and it only rises with one on the four weft picks, 17, 18, 19, 20; the shafts 3 and 4 are for the plain stripe, and shafts 5 and 6 for the ground; these weave plain for twelve picks. Shafts 7 and 8 carry the doup or whip threads, which also weave plain for twelve picks. At the thirteenth pick they combine, and are up for four picks and down for four picks in alternation. During the time of this combined movement, the ground shafts 5 and 6 remain down. The ninth is the position of the slackening bar or rod, which has been introduced to obviate the necessity of employing two warp beams. It will be seen that it rises on the same picks as the doup healds, No. 2, whilst the whip shafts 7 and 8 are down; but the whip threads themselves are lifted to the opposite side of the ground threads, giving the twist or turn required. Of course the "reeding," that is, the drawing of the warp through the reed, of gauze or leno fabrics is specially considered in this case; twenty-four threads would be placed in eleven dents in the following order: four threads in the first dent, and the second dent vacant; again, four threads in the third dent, and another dent left vacant; four threads in the fourth dent, and two threads each in the next six dents. The word dent properly and primarily means tooth, and here indicates the teeth of the reed. It has, however, come to be used to designate the spaces between these teeth, and is so used above. The Scotch term of "splits" would be a more accurate one. The technical terms used in the textile industries, however, like those of nearly every other industry, require a thorough revision and clearer definition.

Very elaborate effects can be obtained with the use of gauze or leno healds, as the warp stripes and the checking can be varied to any desired extent by using a greater or less number of threads for either the plain or gauze effects.

If gauze fabrics are compared with any other cloth constructions, they will be found superior in lightness of

texture and firmness of interlacing, which is due to the partial twist of the threads around one another, and the firm manner in which the weft secures them in that position, enabling the fabric to bear a great strain.

In reference to fig. 101, the draft and weave plan of which is given in fig. 102, if the weft picks are taken in their numerical order, it will be seen that the first raises the doup thread to the right, and the gauze shafts will be lifted, 1 and 2 being raised on this first weft pick. On the second pick the doup thread is transferred to the other side, and the shafts for this are the first and third. The shedding for the next pick is the same as the first; but the doup or skeleton shaft is always up, this being necessary for operating the doup thread by the action of either the ground shaft 2, or the gauze shaft 3. The fourth shaft is always down, as it carries a stationary thread, and may be regarded as an extra shaft only. In fig. 100 the warp threads are drawn so tightly to each other, that the weft pick cannot be drawn up very closely to the preceding pick, so that an open space is left between every pick, and vacant dents being left in the reed to correspond with these spaces, the gauze effect is the result.

The "warp-slackener" or "warp-easer" is a bar or rod which separates the crossing warp from the other. It is fixed at the back of the loom, and may be termed a lever. In the plain weave portion it is inactive; but when the crossing has to be made, a connection on the arm of this rod acts upon the doup heald, causing it to deliver sufficient warp to prevent injury to the other warp threads, after which it is drawn back to its former position by a spring. This method, however, is not suitable for more than the leno fabric in which the doup thread passes under one standard thread only, and in those in which the doup thread passes under more than one standard thread at a time it is necessary to adopt the old system of two beams, in order to diminish the strain upon the doup thread, and the friction upon the doup healds.

The principles and methods thus laid down are generally followed throughout gauze weaving, any departure from them being mainly in the number of stationary threads, around which the doup threads twine, which may be increased as desired. Threads of different colours, or fancy stripes, may be produced to any extent, and gauze and figures, etc. All threads that work the same way can be drawn in on the one doup shaft. The jacquard machine and harness give an almost unlimited variety of figured gauzes; but the improvement in lace frames and their cheap productions, have caused the most elaborate forms of fancy woven gauzes to become an almost extinct branch of weaving.

Jacquard Harness.

In considering the weaves hitherto dealt with it will have been seen that the warp has always been mounted in what have been termed healds, themselves mounted upon and stretched between two staves of wood in number sufficient to meet requirements. A mount of healds of this kind is termed a leaf or shaft, and the number of these required to operate a warp are termed in turn a set of healds. As will be borne in mind, the simplest set is one of two leaves or shafts, advancing up to twenty or even twenty-five shafts; there are dobby machines will admit in extreme requirements up to forty shafts of healds, but the crowded state of the loom requires such a long stretch between the last heald shaft and back rest as to prevent their common use. Beyond these resort is had to the jacquard machine for shedding purposes, owing to its beautiful simplicity and great range of power. In the transition from the preceding system to the new one the terms hitherto used are dropped, and the set of healds becomes the jacquard harness. The simple construction of an ordinary harness is shown in fig. 106. The front now only is given. It will be seen to be composed of several parts: the first, the harness necks shown by the

figures; the couplings shown at the knots, E E; the lingoes or weights, F. The harness necks are connected to the jacquard hooks by passing them through the bottom board of the machine upon which the hooks rest when not in action; these cords are also often termed neck bands. The couplings or knots, E E, shown above the comber board, are a continuation of the neck twines carrying the mails or eyelets, D, through which the warp threads pass, as in ordinary healds. The lingoes, or weights, upon each cord are for the purpose of bringing the warp threads down to their normal position after having been lifted by the hooks in accordance with the shedding requirements of the pattern.

Jacquard harness is full, half, or sometimes otherwise incomplete, according to the nature of the requirements in which it is used. The harness generally in use is the full harness, by which every warp thread throughout the tie if required can be operated singly and independently of the others. In a word it may be called the universal harness, capable of doing whatever can be accomplished by any other build or construction of jacquard mounting. Of course, as in heald shaft shedding arrangements, in the repeats of the pattern the corresponding threads are lifted simultaneously.

There are, as might be anticipated, many varieties of jacquard harness, such as the half, the gauze, the double cloth, the pressure, etc. The half harness has every alternate warp thread drawn in through the mail eye, the other threads only pass through the doups and standard or shaft healds in front of the comber board. This arrangement is used for obtaining a certain class of gauze effects or fabrics. The pressure harness has a given number of warp threads drawn in through each mail eye, which are also operated by heald shafts in order to weave the ground of the fabric. This is no doubt a useful and economical method of forming figures in cloth and saving cards, but it has very serious drawbacks owing to the excessive friction it entails upon the yarn in shedding.

There are two plans of mounting a jacquard on the loom, both suitable for any tie or fabric. These are respectively called the London and Norwich systems, and both have their advocates. The London system arranges the jacquard at right angles with the harness; the Norwich one parallel with it. Our illustrations show the latter arrangement. Fig. 106 shows the front row of a jacquard harness. The horizontal lines A proceed to and are attached to the jacquard machine hooks; B shows the tail cords; C points out the knots connecting the upper and lower portion of the harness; D is the comber board; E the mail eyes through which the warp threads pass, and by which they are lifted to form a shed; and F, the lingoes, or weights, which draw the mails down to their normal position. In fig. 106 only the front row of the cords passing through the comber board D are shown, it not being necessary to exhibit more as all are alike. Now if in mounting the jacquard machine on the loom it be placed with its end to the front or at a right angle to the harness, the mount will be what is called the London plan, which twists the harness cords a half turn around each other. A moment's consideration will show how this happens, for whether the first cord is taken up from the front right or left-hand hole in the comber board, and secured to the front or back hooks of the jacquard machine the cords must eventually cross each other, and the constant rubbing which results in passing each other in forming every shed for the passage of the shuttle must be destructive to the cords. It is said by the admirers and advocates of this arrangement that the half twist it gives to the harness keeps the cords better within bounds, and that a heck or guide can be dispensed with. In the Norwich system the jacquard machine is arranged on the loom parallel with the harness, reed, and cloth, the strands or cords are taken up to the hooks just in the same order as a heald shaft with its complement of warp threads, and when a cord breaks it can be traced at once by separating

the entire row from the next one, which can be done without the slightest difficulty, each row being entire and clear of each other. This is a very useful feature, greatly facilitating such repairs when needed.

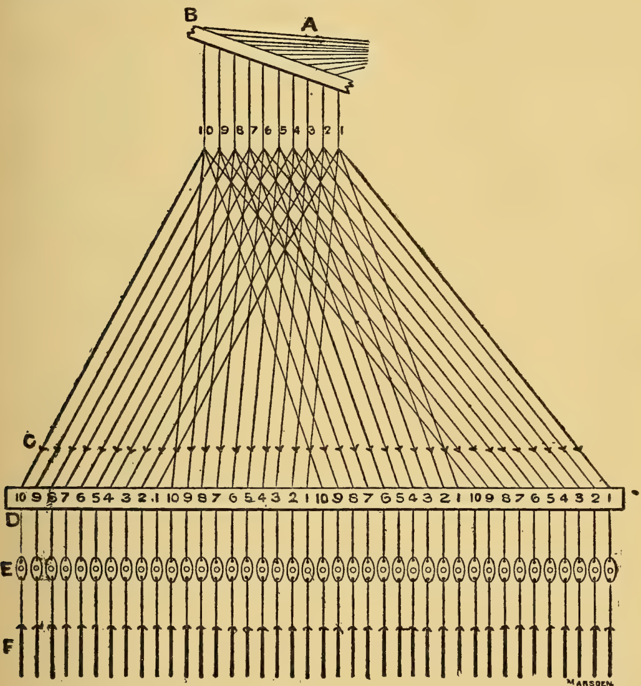


FIG. 106.—JACQUARD HARNESS, FRONT ROW ONLY.

A 400-hook jacquard really contains 408 hooks, the eight beyond the nominal count being allowed for the formation of the selvages of the cloth or other purposes. The 400 hooks are available for operating the warp threads in the production of the pattern across the field of the

cloth to be made. They are, in their ultimate power, equivalent to 400 shafts of healds, as described in the exposition of shaft work, as this number of shafts would be required to produce the same capacity and extent of ornamentation.

The designer who has only 400-hook machines with which to work out his designs is limited by their capacity of work. To extend his designs he might require a 600, or two 400, two 600 machines, etc. In the case of the 400 machine, however, the comber board and the arrangement of the hooks may be taken to be eight holes across, and fifty holes in its length, with every harness cord direct from the mails through the comber board and on to the hooks in the machine, without crossing or chance of coming into contact and causing friction.

The number of holes in the comber board are regulated by the number of threads per inch in the warp, and the function of the comber board is to prevent the harness cords becoming entangled, and to maintain such an orderly arrangement amongst them as to permit of easy working; in fact, the comber board is simply a comb, combing the constantly moving harness cords into order, and from this function it has no doubt derived its name. Irrespective of any peculiar methods of tying up the harness, the comber board is divided into as many sections, or groups of holes, as there are hooks in the machine, though it may be so finely perforated that, as in healds, a given number may need to be left blank to meet requirements.

The ordinary method and the most practical and best in constructing the harness, is to take the tail of the first hook in the machine, and put a cord from it through the first division in the comber board, following with the second and succeeding hooks in a similar manner until all the hooks in the machine have as many cords attached to them as there are divisions in the board. Each of these divisions begins with a complete row, which must always be as fine as the warp reed. The form of the harness will

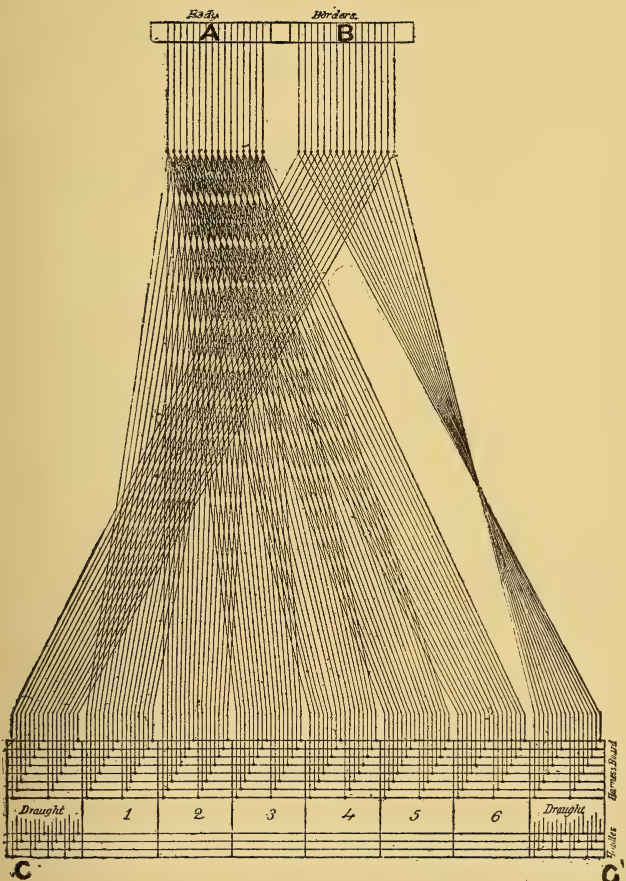


FIG. 107.—JACQUARD HARNESS FOR HANDKERCHIEFS OR BORDERED CLOTHS. NORWICH SYSTEM.

always depend, to a great extent, upon the particular fabric and style required, such as dress goods, double cloths, table-covers, bordered cloths, handkerchiefs, etc.

In fig. 107 is shown the "tie-up," "tie," or harness for a handkerchief, or bordered cloth of any kind, with full drafts and the position of the healds used to work the ground. The twist of the harness cords on the right-hand border is to prevent a reversal of the draft on this border, which would have to be made were it required that the harness should present the same appearance to the observer as it does on the opposite side. By this arrangement the inside of each border presents itself to the centre, or body, of the cloth. A careful study of the illustration (fig. 107) will clearly reveal this to the reader. It shows the body harness at A for weaving the central design of the fabric; the border harness at B and at C and C′ shafts for weaving a plain or twill ground.

It is a common practice to build a harness with such a tie as will admit of a great variety of patterns for several classes of fabrics, and then to get the designer to work, if possible, within their capacity. Of course this is from an economical consideration, a motive which though very praiseworthy should not always have absolute control.

Damask Weaving.

In the preceding sections of this chapter, the power accruing to the textile fabric designer from increasing the number of his heald shafts has been shown. It was not deemed necessary to carry the exposition beyond a ten shaft set of healds, as the student who has mastered the details up to that point can easily travel to the boundary of shaft work himself. Also it may be remarked that every further addition to the number of shafts increases the cumbrousness of the system, and with all the necessary complement of shedding mechanism takes up so much

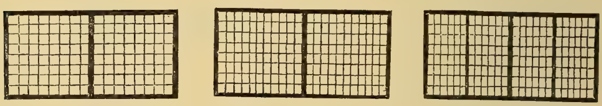
space that an alternative method soon becomes highly desirable. This is found in the jacquard machine, a wonderful invention of the early part of the present century, of which a description will be given subsequently. This machine, as observed in a preceding page, practically gives the designer perfect control over the actuation of every thread in his warp, so that he can shed it independently of any other thread should he so desire, or the exigencies of his design require it. The great advantage thus resulting for the production of ornamental designs will be obvious at once.

It is in the production of the large floriated designs of damask fabrics that the designer is soon carried beyond the range of shaft work. When designs are wanted that pass beyond the scope of the latter, the sketch must be regulated by the nature of the texture required, and the size of the jacquard machines at command. Let it be assumed that a design is suitable for a 400-hook machine, and that the fabric must contain eighty warp threads per inch, by making 80 the divisor of 400 a quotient of 5 inches is arrived at, which gives the width of cloth available for one pattern. The length of the pattern depends upon the number of picks put into it, and may run to a great length. The number of picks to the round is governed by the pattern cards.

In the preparation of an original design, it is always best to make two or three repeats both in the warp and weft threads, as then, should the design prove weak in any respect, or fail to join in a satisfactory manner, the fault is easily discovered and remedied. The ornamental figures with which it is the object of the designer to decorate the fabric should, if possible, be so distributed upon the surface as to avoid the production of parallel, diagonal, or transverse rows. This can best be attained by the use of a weft sateen, or warp satin arrangement.

When it is necessary to transfer a sketch to point paper, the sketch is ruled or lined in squares to correspond with

the paper, so that it can be enlarged very accurately. If a pattern is required to be copied from a fabric or drawing, then tracing paper must be used, which, placed upon a sheet of white paper, may be ruled in spaces as required. Suppose the sketch has been drawn upon point paper to appear as a cloth with sixty threads per inch, the same as the sketch, then the figure ornament must be enclosed in a square, and if it measures ·75, or three-quarters of an inch in length, and ·5 or half an inch in width, there will be in it forty-five weft threads or picks, and thirty warp threads in the entire pattern. Those who do not find it easy to rule a sketch in this manner, will find point paper a very reliable guide. Now to take this sketch upon the commonest type



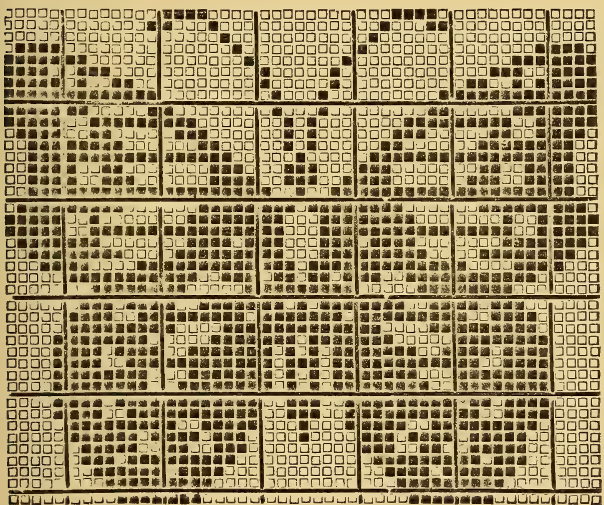
8 × 8 8 × 11 8 × 12

FIG. 108.

of point paper in use, 8 × 8 in one division—that is eight threads of warp and eight threads of weft in one of the large squares, the pattern would fill five large squares, and have five picks over in the weft way, the latter, of course, running into another square; and three large squares with six threads over in the warp way, the latter, like the weft picks, running into another large square to complete. An exact size of the sketch is thus reproduced.

Of design or point paper there are many types. Three are shown in fig. 108. It will be seen that they vary in the number of lines for weft threads. Let it be supposed that it is required to put upon paper a design containing 80 warp threads and 120 weft threads per inch, the design paper would require to be 8 × 12;

if 100 weft threads, 8 × 10, and so on in proportion. Should a 5 × 5 design be required for a fabric, 80 warp threads by 120 weft threads, the sketch would have to be enlarged so as to cover 400 warp and 600 weft threads; that is, 80 × 5 = 400, and 120 × 5 = 600, which would all be represented by the squares. The



BUTTERFLY DESIGN.

FIG. 109.

simplest method of procedure, however, taking this as an illustration, would be to rule off on ordinary paper, 8 × 8, 400 × 600 squares, and trace the design by impression. Take, for example, the figure of the butterfly (fig. 109), which was drawn direct upon point paper. If required for a stripe, it could be produced on a dobby by a V-draft, without alteration of the figure, and with a plain ground intersecting its recurrence for a few picks. In

such a reproduction twenty-five heald shafts would suffice for the figure, and four for the ground weave. But this design has been constructed for an "all-over" effect on a satin ground, each figure to be placed in position by a satin arrangement. Space, however, will hardly permit an extended description of this illustration; it must, therefore, suffice to say that the ground and figure must be a measure of each other. An examination will show that the figure covers forty-nine threads from left to right, so if a seven-shaft satin be taken for the ground, $7 \times 7 = 49$ shows the ground and figure with this would be in unison, and the joinings would be effected without a break. In its length, or weft-way, the design covers forty-one squares or picks, and as the figures require to be separatod from each other, if eight satin picks are added thereto for this purpose, forty-nine, or the same number of threads as in the warp would be used, the ground and figure thus measuring alike.

In jacquard harness there are no complex drafts, all are straight over. The pattern or design must, if possible, cover a number of threads that will be a multiple of the number of hooks in the machine. If this cannot be done, what is termed casting-out must be resorted to. This means that a given number of jacquard hooks must be thrown out of action all the time. Thus, to revert to the butterfly illustration, it has been seen that forty-nine threads cover the figure. If this was made upon a 200-hook machine, four repeats would occur, with four of a remainder, thus $200 \div 49 = 4 + 4$. These four hooks would have to remain out of work all through the width and all through the length of the warp. The same thing occurs in all cases in which the threads in the design cannot be divided by the machine hooks without a remainder.

Besides the "casting-out" thus shown, a further necessity for resort to it arises, as in healds, owing to the exigencies of orders. The harness when built, whether on

the London or Norwich principle, cannot be cut down and rebuilt to suit every change of density in the texture of warp threads per inch. It is always built to a certain proportion of threads per inch, and if a less number than this is required in a fabric, the unnecessary ones may be cast or left out in the drafting. But there is not the same liberty in the opposite direction: under no circumstances can any be added. This being the case, and the reed being a controlling factor, it becomes merely an arithmetical calculation under the rule of proportion. Take, as an illustration, the case of a harness tied up to weave ninety threads per inch, but the order in hand is for a fabric to contain eighty-six threads per inch. Therefore if the jacquard machine is a 400-hook, the problem stands as follows: As 90 : 400 :: 86 = 382. Subtracting 382 from 400, there are 18 left, which is the number of mails in the harness, holes in the comber board, and hooks in the jacquard that will require to be left vacant. These remarks will be sufficient to show how design figures and lower reeds may be adapted to the capacity of the harness and jacquard machines, however many hooks they may have from 100 upwards.

The Analysis or Dissection of Woven Fabrics.

It often happens in actual practice that manufacturers have samples or patterns of cloth submitted to them for imitation, or "matching," as it is usually called. These often spring from some interruption of communications with the sources of the original supply, which may arise from many causes.

The points to be noted in order are, 1st, the dimensions, which simply mean width and length; 2nd, the substance, which implies weight of the warp, weft, and the sizing materials; 3rd, the quality of the yarns, and the composition and quality of the sizing materials; and 4th, the

texture or weave. To ensure a satisfactory result all these points require careful examination, which can only be made by dissection, and from the knowledge thus gained accurate reconstruction on parallel lines will result by the use of proper care. It will not be enough for even the most clever experts to merely glance at a piece of cloth, count the warp and weft, and then proceed to make it from such meagre details, disappointment and dissatisfaction will almost surely result.

With the knowledge of cloth construction gained from the examples already given, in which it is traced from its simplest to moderately intricate forms, and their practical application shown, the dissection of samples will be found both simple and easy. In the simplest weaves a mere inspection of the fabric will suffice to reveal what the weave is, but in intricate patterns a much more careful procedure becomes necessary, and the following instructions should be carefully observed :—Take the sample of cloth, or a portion sufficiently large to contain an entire round and a small portion on each side. Draw from this several threads both of warp and weft, so as to leave a short fringe of both on their respective sides. This will facilitate the examination. Commence the operation by pushing back a weft thread (not pulling it out) from its position near the other still in its place. Proceed to count the intersections this pick makes with the warp threads from the right to the left. In taking out the pick all the threads of the warp which the weft passes over must be marked in their regular order on the point paper until a repeat occurs, which will be shown by the weft going over in the same order as before. In fig. 110 is given an illustration, with the warp and weft threads numbered. In relation to the first weft pick it will be observed

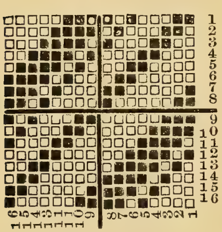


Fig. 110.

that the first two warp threads are down, three next up, one down, one up, four down, and five up. The first pick having been carefully taken out and registered, proceed as before from the same point. Here the first warp thread is up, next two down, three up, one down, one up, four down, and this is marked No. 2 on the point paper. The dissection is proceeded with in this manner until a pick is found, which repeats the positions of that first taken out and marked No. 1. Thus the round or repeat of the fabric in the weft way is found. The weave plan shows sixteen shafts or warp threads and sixteen picks of weft as the round, forming a fancy twill with the angle to the right, which is its proper inclination. The warp threads or shafts numbered show the draft to be straight over the healds, and as no two are alike this draft cannot be reduced. This illustration shows the whole process of dissection to be pursued in any weave, however complex it may be. The fringe of warp yarn will show the colour pattern, if any, and the weft pattern, if in colours, can be seen in the weft fringe. These colours and their order of succession must be written down in detail, for "costing," that is, ascertaining the cost of producing it, dyeing, warping, etc. The threads of warp and weft may be compared with well-known standard counts to discover their numbers, or better still, be accurately ascertained by means which will be found described elsewhere in these pages. If in the sample submitted for dissection the selvages are absent, the warp threads can usually be distinguished from the weft by being harder twisted, by the size upon them, and generally by being of coarser counts. Samples are sometimes dissected by taking out the warp threads and leaving in the weft picks.

We close this section with an illustration, fig. 111, of the manner in which the simple weaves that have been expounded in this chapter can be utilized for the production of variegated effects suitable for many purposes. The example given is an extract from the "Textile Mercury"

of December 9th, 1893. It is a rich and beautiful design, primarily for ladies' dress goods, but suitable for many other purposes. It is a combination of the powers of the four-shaft twill, and besides being of practical value to the manufacturer as given, constitutes an exceedingly

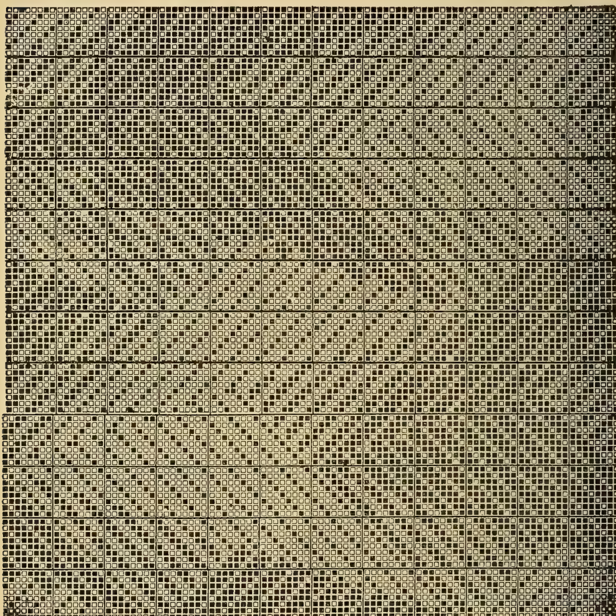


FIG. 111.—DESIGN FOR LADIES' DRESS GOODS.

valuable example to the textile student, offering an excellent study full of suggestiveness as to what may be accomplished on the same lines with other twills. If the powers of a higher twill had been employed the permutations would have become enormously greater and richer. The design as given, however, would look exceedingly well in

many classes of fabrics besides dress goods, and in many materials. The exigencies of page space have compelled the reduction of the design to rather small dimensions, but it is sufficiently clear to answer all requirements, whilst it gives a nearer approximation to its actual effect in a woven fabric than if set in larger type.

CHAPTER V.

The Modern Power-Loom.

The power-loom perfected in principle in 1841; subsequent improvement in details.—Fast reed looms *illustrated* and described in detail.—The warp protector.—The loose reed loom, *illustrated*; detailed description.—The picking motion; the shedding motion; furnishing the loom with warp; the process or mechanical action of the loom in weaving.—The speed and production of looms.—The weaver's duties.—The beauty and productive capacity of the loom, and the advantages resulting therefrom.

HAVING dealt with the principles of weaving, the instrument by which weaving is performed must now be considered. This is the modern power-loom, whose development has already been traced from its germ in the most ancient times to the period when it became a perfect automaton. This was in 1841, when the inventions of the late James Bullough, then of Blackburn, and afterwards of Accrington, added the last requirements needed to complete it, the automatic stopping motion known as the weft fork, the self-acting trough and roller temple, and the friction-driven cloth roller. Great improvements have since been effected, but they have been in details, and have gone to render more perfect in form, and more effective in power, the component parts of the loom which were already complete in principle. In many cases new, original designs have supplanted those first introduced. These have in the main been directed to enlarging the loom's capacity of production by increasing its speed, improving its control of the warp in shedding, and extending the range of its picking and shuttle-carrying power. So great have been the improvements in these respects that it may safely be said that there is nothing in the way of a woven fabric

that is now beyond the capacity of the power-loom to make. These statements will be found to have been amply demonstrated in the course of this treatise.

In figs. 112, 113, two views of a well-constructed fast-reed loom for weaving the heavier descriptions of plain cloth are given. These very effectively represent the loom

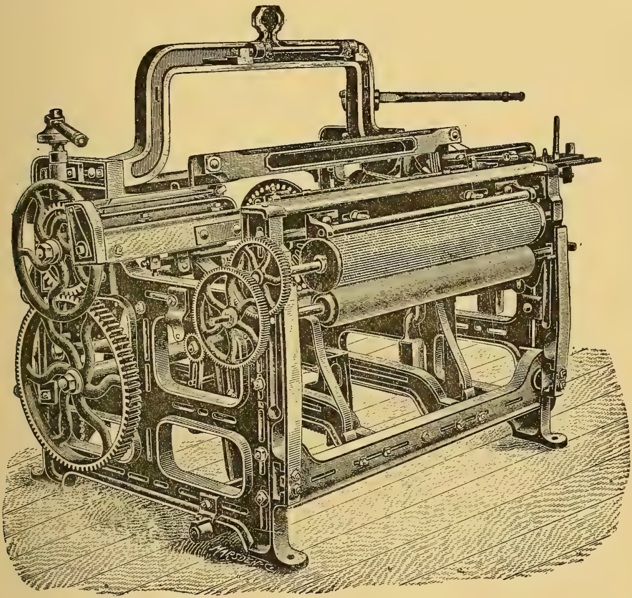


FIG. 112.—MODERN FAST REED LOOM. FRONT AND GEARING END VIEW.

of to-day in both its strength and excellence of construction. As it is the machine itself that is under consideration it has not been thought desirable to include a representation of the warp along with it. The next illustration, fig. 114, is one of a similar class of loom, but on the loose reed principle. This type being very widely diffused and

extensively used may properly be selected for detailed description. The illustration shows the working parts of a plain loom, and as this is the foundation on which what are termed "fancy looms" are constructed, its description will suffice for all except in the parts that are added to secure particular or special results. The framework, *a*, roughly speaking, describes the figure of a cube if the head or top be ignored. Within this frame, attached to the sides or bearing on them, are the working parts. The first shaft carrying the balance-wheel, *b*, extends through the centre of the frame, and projects about 8″ to 18″ beyond, this projection being for the reception of the driving pulleys, one fast, the other loose. A brake wheel is also usually carried upon this part. The shaft has its bearings on the sides of the frame. On the end opposite to that carrying the driving-pulley is mounted the driving or first spur wheel just outside the frame and between it and the fly-wheel, *b*. Just within the frame, at each side, the shaft is cranked, and by means of arms from these cranks is attached to the "slay" or lathe, *c*, which oscillates upon the "slay-swords," *h*, to which it is attached, the latter being carried upon the swing or rocking-rail, *i*, which forms their centre or pivot. The slay or lathe, *c*, has several parts. Its upper surface from end to end forms the shuttle race, the ground over which the shuttle passes backward and forward from one box to the other; this is slightly inclined towards the reed, to ease the formation of the shed. The reed occupies the space, *d*, its frame fitting into grooves at the top and bottom. At the top it is retained in position by the slay-cap, *e*, at the bottom by a similar groove in the slay-block; but in the case of a loose reed, as in the loom depicted here, there is a retaining-board, which is movable, and permits the reed to be pressed out at the bottom when obstruction of a sufficient force occurs in the warp shed. This is to prevent extensive breakages of the warp threads, or "smashes," as weavers term them. At

this point a short pause may be made to explain the difference between the loose and fast reed looms.

In the case of the fast reed loom shown in figs. 112, 113, there is a warp protector consisting of a projection, sometimes two, placed upon a horizontal rod, called the stop-rod, attached to the underside of the slay-block, and running

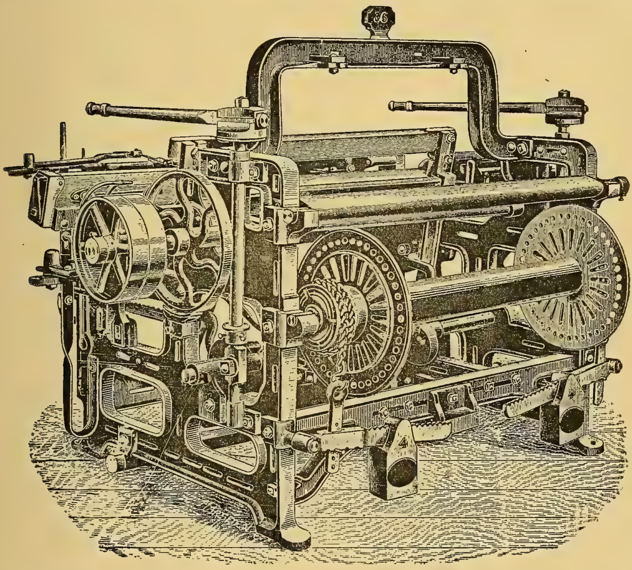


FIG. 113.—MODERN POWER-LOOM. BACK AND DRIVING END VIEW.

its entire length. Behind each shuttle-box, fixed upon this rod, there is a bent lever, which curves up to the back of the shuttle-box, where it presses against the rear of a swell placed within the shuttle-box back. This it pushes into the box to its normal position. In this state the projection on the rod, termed the "protector," is depressed into the position placing it on guard, and unless it were raised from this

it would not permit the slay to advance to the edge of the cloth to drive home the newly inserted pick of weft. The shuttle on its passage to and fro does this every time it properly enters the boxes. Wanting the space the swell has taken up within the box it pushes it back, and this in turn presses back the curved lever upon the stop-rod, causing it to turn through a small segment of a circle, which has the effect of lifting the face of the protector over the face of a stop-block, called a "frog," from a rude profile likeness to the frog of our fields. Should the shuttle fail to clear the warp shed in time the protector is not raised and comes into contact with the stop-block, which instantly arrests the advance of the slay, and thus prevents the breakage of the warp that would otherwise follow. The shock that takes place on this impact is a severe one, and when looms were made with a lighter frame than is the case to-day the loom sides were occasionally broken, which was a much greater damage than would have been the smash of the warp. Even now it is deemed prudent to provide against this risk, and the front view, fig. 112, shows two vertical, strong, flat springs, termed front springs, on the front of the frame, which soften the concussion, and relieve the frame from risk of breakage. To return to fig. 114, the shuttle-boxes are formed by the metal plate, *f*, a board forming the back, and the end plate of iron which is fixed upon the extremity of the slay-block; the bottom is composed of a slotted plate of iron laid upon the slay-block itself, which for the length of the box has a groove cut into it for the reception of the picker foot. To complete the equipment of the box the fly-spindle, *g*, is required which has one end inserted in the spindle-stud slightly to the left of the letter *d*, the opposite end passing through the box end into a "pap" or socket upon the top of a flat spring secured by a screw bolt to the end of the slay, *c*.

The taking-up roller, *j*, is actuated through the train of wheels shown at the end of the loom by the oscillation of

the slay communicated through the pin, *l*, attached to the slay sword, *h*, and working in the slotted lever, *m*, called the taking-up lever. On the top of this lever is a catch termed the taking-up lever catch; this is a misnomer, for it is rather a propeller pushing the ratchet wheel around, one tooth at a movement. As the wheel is pushed forward, a retaining catch takes hold and keeps it in the position to which it has been pushed. This taking-up

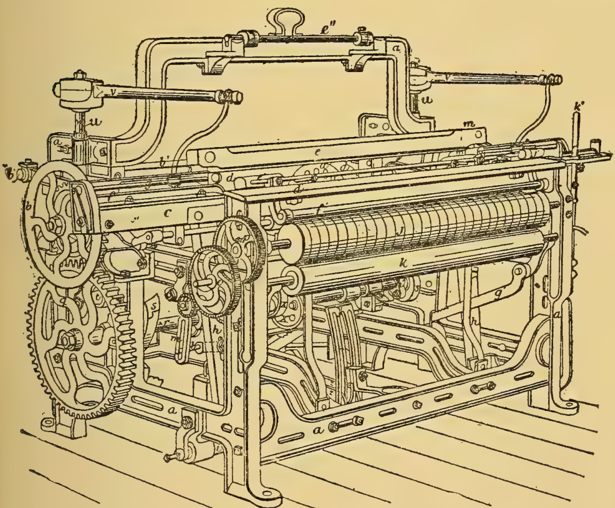


FIG. 114.—MODERN LOOSE REED POWER-LOOM.

gear is a very important part of the loom, and on this account will be brought under notice subsequently along with improved variations of it. The stud carrying the rack wheel passes through a bracket to the outside of the loom frame where it receives the change pinion, *n*, and from this fact is called the pinion wheel stud. This pinion gears into the carrier wheel, *o*, which is loose upon its stud, and has a pinion cast upon its boss that in turn

gears into the beam wheel, *p*, keyed or fixed with a set screw upon the axis of the taking-up roller, *j*. The quantity of picks put into the cloth is governed by the number of teeth contained in the change pinion, *n*; the smaller the number the more are the picks put in; the greater the number, the fewer will the cloth contain. To save reference we may here briefly observe that the rack wheel in the ordinary system of taking-up gear contains 50 teeth; the carrier, or stud wheel as it is sometimes called, 120, the pinion 15; and the beam or taking-up wheel 75 teeth, the circumference of the beam being 15 inches. These particulars worked out in the usual manner, and including an allowance agreed upon in the formation of the standard list for weaving, give a constant number of 507, termed the dividend. The change wheel, *n*, may have any number of teeth, but when the cloth requires a very large one, the effect is often obtained by giving the actuating catch a double lift, that is, making it take up two teeth at once. The taking-up roller, *j*, drives the cloth roller, *k*, by friction, winding up the cloth as it is woven. Contact between the two rollers is maintained by the weighted levers, *g*′. This taking-up movement is obtained from the crank, or driving shaft of the loom, as it is indifferently called, delivered through the reciprocating movement of the slay.

The tappet shaft drives what may be termed the second half of the mechanism of the loom. The crank shaft carries upon one end a spur wheel, which gears into and drives the tappet shaft, *r*, through the large spur wheel, *q*, fixed upon its end, and termed the tappet shaft wheel. The crank shaft wheel usually contains thirty-seven teeth, and the tappet shaft wheel twice that number. The crank shaft therefore makes two revolutions for the tappet shaft one. The reason for the diminution of the speed will soon be obvious. Both the picking and the shedding motions require it. On the shaft, *r*, immediately inside the loom frame, are the picking cones or plates, *s*, one at

each side, formed of two pieces termed the plate and the neb or pick point, the latter being case hardened. As the shaft, *r*, revolves, it carries these around, and in each revolution they strike their respective bowls, *t*, carried on studs on the bottom of the vertical picking shafts, *u*. The picking plates are set upon the shaft, *r*, with their points exactly opposite to each other so that their strokes upon their bowls shall accurately alternate. The sharp impact of the cone point, *s*, upon the bowl, *t*, causes the vertical picking-shaft, *u*, to make about one-third of a revolution, and this carries the head of the picking-stick through the corresponding arc of a much larger circle. This is a very quick action and shoots the shuttle through the warp shed. When the shaft, *u*, is at rest the picking stick, *v*, carried upon its top, has its head, *w*, over the end of the shuttle box, *f*. The partial revolution of the shaft, *u*, caused by the impact of the revolving picking cone, *s*, sharply sends the picking-stick forward to the position shown in the left-hand side of the illustration. A leather band, termed the picking band, descends from the head of the picking-stick, *w*, to the picker upon the fly spindle, *g*, the sudden drag upon which projects the shuttle through the warp shed to the opposite box, whence it is returned by the corresponding action of the opposite side. This reciprocal action constitutes the picking motion of the loom.

The shedding motion next invites attention. This is performed by the tappets, *x*, which are two eccentric cams cast together on one boss carried upon the shaft, *r*, and from which it receives its name of the tappet shaft. These as the shaft revolves alternately depress the treadles, two levers which have their fulcrum upon a pin in the back or front cross rail of the loom as may be arranged; in the present illustration it is the back position, but the loom being without its warp, they are only shown out of their working position with their ends, *z*, at the bottom of the treadle grate, *y*. When the beam, *a′*, which is seen to much better effect in fig. 113, contains a warp, the

latter is drawn over the carrier beam or roller, b', the healds are suspended upon the heald roller, e^2, by means of cords attached to straps securely fixed upon its bosses, the other ends being attached to the heald shafts. Similar cords on the bottom staves of the healds form through what are termed lams a connexion with the treadles.

Whilst this illustration is before the reader, the operation of weaving may be briefly described as it would be performed were the loom it represents in a proper site and connected with the necessary driving power. A warp with the requisite set of healds and reed having been placed in position is drawn forward, the healds are hung upon the heald roller, e^2, the reed is secured in the space, d, the warp is drawn over the breast beam, d', whence it passes obliquely down and under the roller, f', though this is not a necessary or even frequent appendage to the loom, only being occasionally introduced to increase the grip of the taking-up roller upon the fabric, when strong cloths are being made, by bringing it into contact with a greater portion of its periphery. The cloth thus passes around about two-thirds of the taking-up roller and upon the cloth roller, k, where the end is secured in a slot by means of a rod extending across its length. The temples, e', are adjusted, and the healds tied up so as to shed properly, with such other little arrangements as the specialities of the case may call for, and then the loom is ready for work.

The shuttle is supplied with weft, placed in the box, the spring lever K′ is pushed to the opposite extremity of the slot where it is retained by a detent. This movement of the spring handle K′ actuates the strap fork which carries the strap from the loose to the fast pulley of the loom, causing the latter to commence work. The following motions then simultaneously and in harmonious order take place: The slay is sent forward and withdrawn by the crank shaft, the warp is shedded or opened by the tappets, and the shuttle is projected from one side to the other

through the open shed leaving a thread of weft in its track. The slay again advancing carrying the reed presses home the weft thread to a given position near the temple roller, at which the warp closes upon it, securing it there. This completes the first series of movements, which are then immediately recommenced. The slay retires and the shed opens in the opposite direction, the warp threads that were up before being now down, and the ones that were down being now up. The shuttle is thrown back to the box from which it first started, again leaving a trail of thread behind. The slay again advances and drives home the weft, completing the insertion of the second pick. The continuity of these simultaneous and successive movements constitutes the operation of power loom weaving.

The speed of a loom is described by the number of picks —the times it throws the shuttle across the warp—per minute. The plain loom as illustrated and described here will pick 200-240 times per minute, according to its width, which is measured by its reed space. Widths ordinarily range from 26 inches to 60 inches, widths below or above these dimensions being of special requirement and construction. The narrowest looms run the quickest. A loom working at 240 picks per minute will weave 3″ of cloth per minute containing 20 picks per quarter inch, or allowing 10 per cent. for stoppages, for piecing broken warp threads, changing shuttles and a number of other small matters, 45 yards per working day of 10 hours. Therefore one weaver superintending four looms of this kind—a very common thing—would produce 180 yards of such cloth per day, or say 1,000 yards per week, and 50,000 yards per annum, working fifty weeks in the year.

It will have been seen that the loom is perfectly automatic in its operations, wanting only the power derived from the steam-engine, and a little supervision by the attendant, who is called the weaver, but to whom this name no longer properly appertains, he or she being simply an attendant upon an automatic weaving machine. The

loom when the weft in the shuttle has been exhausted automatically stops, and the duty of the weaver is to replenish the shuttle or substitute a filled one and restart the loom. Two shuttles are allowed to each loom, one to be kept ready filled to replace the exhausted one, so that time and engine power may not be wasted as would be the case were the loom to be kept idle until the shuttle was refilled. The loom of course may stop for other causes, or owing to the breakage of warp threads, or other matters going wrong, of which it cannot automatically take cognizance, so may require to be stopped by the attendant, who for convenience may still be called the weaver. The duty of the weaver is to keep a strict supervision over the looms committed to his or her charge in order to prevent matters going wrong. Owing to the perfection to which looms have been brought, they require comparatively little supervision at the present day, so that weavers can now tend from two to six looms each according to the character of the work being performed.

This beautiful automaton, the power-loom, may justly be regarded, even in its simplest form as here described, as one of the wonders of mechanical science. It has a still greater claim to man's estimation owing to the enormous degree to which it has relieved him from laborious drudgery. The extent to which it has accomplished this will be seen in the fact that a good hand-loom weaver of the past days would never and could never for any length of time together make more than fifty picks per minute, whilst the power-loom's capacity is from 180 to 260 picks per minute, according to the widths of cloth being made. In some branches of the worsted trade the speed has attained 400 picks per minute. Thus at an easy estimate each power-loom is equivalent to five hand-loom weavers, and as four of these looms on an average can be superintended by one power-loom weaver, it follows that one person with the aid of power-looms can produce as much as twenty weavers of the early days of the present century.

But even this estimate falls far below the facts because the hand-loom weaver was never a persistent worker, whilst the power-loom is absolutely tireless, working as well at the close of the day as at the beginning, and if necessary it could work all round the twenty-four hours of the day, and the seven days of the week. The quality of work produced from the power-loom is also uniformly much superior to that which could be obtained from human labour. Such is the power-loom of to-day: to its creators the world is deeply indebted; it has emancipated millions from the drudgery of a sedentary labour task, it has brought clothing within the reach of millions more, who, without its aid, would never have been able to shield themselves from the cold and heat of the varying seasons and of the different climes of the world. Many more if clothed at all would have had to go about in rags and tatters, as the periodical renewal of the clothing of the greatest portion of the populations of nearly every civilized country would have been impossible on account of the expense. It was no uncommon practice a century or two ago to hand down personal clothing from father to son and from mother to daughter amongst the lower classes, whilst amongst those socially above them, the contents of the wardrobes were carefully bequeathed for distribution amongst the friends of the deceased. This was a practice that from a sanitary point of view was decidedly objectionable, whilst from an æsthetic one it was still more so. Fancy the present generation of Englishmen and women promenading in the cast-off clothes of its recent predecessors. Yet this is what the modern power-loom has saved them from. The rags and tatters and patched clothing that formerly distinguished the working classes have almost everywhere disappeared, for when clothing has been so far worn as to require patching, the wearer in the humblest sphere of life can now in almost every case afford to renew it.

CHAPTER VI.

The Development of the Shedding Motion.

Specialization of cotton manufacturing.—Shedding power of the loom; plain cloth, *illustrated.*—Four-leaved twill, *illustrated.*—Spring headpiece, *illustrated.*—The cylinder motion.—Jamieson's shedding motion, *illustrated.*—The Bradford shedding motion, *illustrated.*—Fustian loom with Woodcroft tappets, *illustrated.*—The draw-loom.—The drawboy machine.—The jacquard machine.—Joseph Marie Jacquard, brief sketch.—Introduction of the machine to England and rapid spread in the weaving districts.—Variety of types.—Sizes of the machine, how expressed.—Double-lift jacquard, *illustrated.*—The parts of the machine described and *illustrated;* the hooks, the needles, the griffes, the batten, the cylinder, the card.—Function of the cylinder.—Hooks and needles as combined for work, *illustrated.*—Function of the cards.—The needle-board and lintel-frame.—The spring-box, *illustrated.*—Various types of jacquards, single-lift, double machines, compound machines, and leno machine, all *illustrated.*—Brierley's improved driving arrangement, *illustrated.*—The dobby, a modified jacquard.—Its development.—Hattersley and Smith's dobby, and Eccles's, *illustrated.*—Various types of dobbies.—The patent cardless, automatic, cross-border, combination dobby, described and *illustrated.*—Its great capacity for the production and variations of patterns.—Patterns, *illustrated.*

HAVING described in detail the automatic power-loom in its simplest form, the task may now be taken up of tracing its further development in a very important respect, namely, its shedding power.

In the cotton trade, where the manufacture of the various cloths is, to a large extent, specialized or confined to particular classes of manufacturers, business goes on with comparatively few changes. Consequently the man who makes the production of plain cloths his staple pursuit is rarely prepared to undertake orders for even the simplest twills, this needing an extension of the shedding capacity of his looms which he has not provided. Again,

another manufacturer may equip his looms for the production of cloth from plain up to five or six-shaft twills. Others, again, who do what is termed a mixed business, will furnish their establishments with looms of various capacities so as to be able to undertake any orders that may be offered to them. It should be borne in mind, however, that the different varieties of cloth are most economically and advantageously made upon looms that are specially suited to them, as in the use of a loom, the full capacity of which is not brought into activity, there is generally some mechanism to actuate, or weight to carry, which involves the expenditure of steam-power without any return; and further, the capital represented by this portion is put out of use, for the time being, and lies unproductive. This, of course, involves waste that ought, wherever possible, to be avoided. The best manufacturers and managers will constantly bear this in mind, and the student will do well to do so likewise.

What is meant by the shedding power of a loom is its ability to raise and depress the threads of the warp, in the manner required to meet the necessities of the design intended to be woven. As shown in the loom just described, this capacity is very limited, consisting merely of simultaneously raising one half of the warp and depressing the other to a similar extent, to allow of the passage of the shuttle between. In ordinary practice the threads of the warp being alternatingly placed in the ascending and descending heald shafts produce the plain fabric shown in fig. 23, *ante*, p. 103, and delineated in design, fig. 24, *ante*, p. 104. It is produced as shown in fig. 115, which shows the whole arrangement. The tappets, A B, as before described, are carried upon the second or tappet-shaft of the loom, and in revolving A depresses the treadle, C, which latter, through its connection with D, by way of the heald roller, E, as shown, elevates D. In turn D is depressed in the same way, and correspondingly elevates C. This is the simplest form

of the shedding process, and however complex it may become, as will be shown in the description of the more intricate developments, the principle remains the same. It should, perhaps, be remarked here, that in all cases where there are heald rollers, as at E, the movements of the healds are rendered as easy as possible by being counterpoised with one another. This advantage is lost

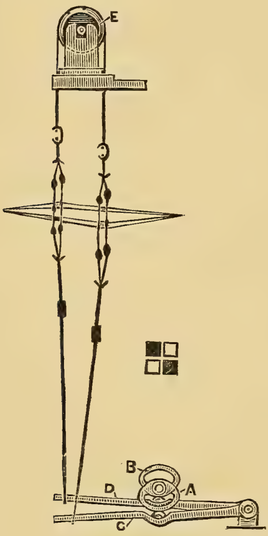


FIG. 115.


FIG. 116.

when the shedding arrangement becomes more complex, but it matters comparatively little in the latter cases, as the weight to be moved is much diminished, at least until the lingoes of the jacquard come in.

It would occupy far too much space to trace in detail every forward step made in the shedding power of the loom, but progress has been steady, and very seldom interrupted for any length of time. It will serve the

present purpose if the tappets and top motion, the heald roller arrangement, of a four-shaft twill be described, premising that up to about six shafts they are all of the same type. Fig. 116 shows the head-gear and tappets and design of a four-shaft twill in which the arrangement is for a tread of three shafts down and one up. A four-twill tappet can be arranged to tread two shafts down and two up, and one down and three up. Similar arrangements can be made in others as may be desired.

After a certain number of shafts, say about six, have been reached, a top motion or head-gear on the roller principle, as shown, becomes cumbrous, and what is termed a spring top motion was formerly much in use.

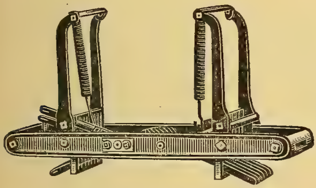


FIG. 117.

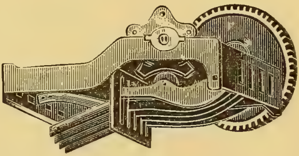


FIG. 118.

One of these is shown in fig. 117. As will be seen, it consists of a small iron frame, having within it a number of compound levers, each series pivoted upon a common centre. The two series individually connect with each other in the middle of the frame by means of sector ends. Each lever is attached to a helical spring, as shown, which holds them up, this being their normal position. By means of cords depending from their under side they are attached to the heald shafts, which similarly from their bottom staves are connected with the treadles. The tappet forms the shed in the usual way; when released the spring in the headpiece draws the heald shaft back to its first position. This spring headpiece can be made for any number of shafts. The type of tappet already shown has also to be modified or much reduced in size.

An excellent treading arrangement, and of great capacity, was one well-known and extensively in use thirty years ago, called the barrel or cylinder motion. It came near the jacquard machine in its capacity for variation within the narrow range of stave work, but it was somewhat cumbrous to work and especially to change, and therefore disappeared when the modified jacquard known as the dobby came into the field. As it is not at present in use no further time need be spent in its description. It is interesting, however, as having been the invention of Richard Roberts.

Where it was desired to retain the tappet treading arrangement, the motion of which is an easy glide from one position to another, and therefore rather less severe upon the warp, a later invention, known as Jamieson's treading motion, afterwards came into favour. This is shown in fig. 118, and consists of the requisite number of tappets and treadles of the ordinary type, much reduced in size, arranged in a frame and operated through gearing connected with the second shaft of the loom. These tappets could be adjusted to tread in any order required. With the improvement of the dobby machine this also has practically disappeared.

Another arrangement of multiple tappets is that known as the Bradford treading motion. It is in great favour in the Yorkshire districts in weaving woollen and worsted, or mixed materials in dress goods because of the facilities it offers for making changes. In the cotton trade, where the orders run much larger on a design or figure, it would be objectionable on account of the extra space it requires. As will be seen in the illustration (fig. 119), the tappets, are arranged outside the loom, which permits of their being very easily taken off when changes are required. From the ends of the treadles connecting-rods ascend to the levers carried upon the horizontal shafts which carry the quadrant levers. To these the healds are attached, and are lifted in the order of the tappet arrangement.

Any of these shafts can be thrown out of action when not needed, the remainder being available for weaving fabrics requiring any number of shafts up to the full complement that the arrangement may contain. All that is required beside is to simply change the tappet and wheel. This illustration shows the loom with revolving shuttle-boxes.

In the manufacture of very heavy fabrics, where a num-

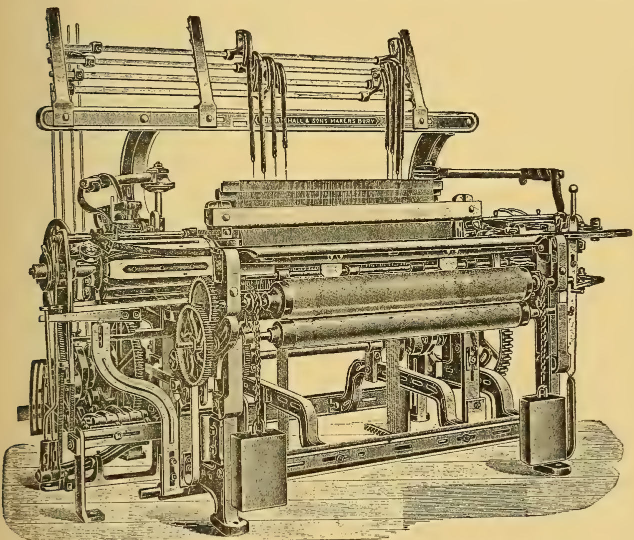


FIG. 119.—LOOM WITH BRADFORD SHEDDING MOTION.

ber of shafts are required for the purpose, it is essential to have looms with very strong frames, and all the appointments to correspond. These looms are termed fustian and heavy fabric looms, and usually have several special motions not frequently seen in most other looms. In the generality of cases, however, they are furnished with a special treading motion known as Woodcroft's section tappets, from the name of the patentee, the late Mr.

Bennet Woodcroft, who, however, we believe was not the inventor. It is shown in fig. 120.

This treading motion is arranged on the outside of the loom frame. It is built up of a number of plates or discs, which are perforated to permit the easy attachment of certain parts termed sinkers and risers, from the fact that through their connections they elevate and depress the healds in the manner required by the pattern. Underneath the loom are a set of jacks or levers to which the healds are connected. A corresponding set are mounted upon the top of the loom, and connections formed between them and the treadles, which in the illustration are seen upon the cylinder at the end of the loom, and which is formed of the combination of tappet plates. When these plates have been arranged for work they present to the treadles, if we may use a homely illustration, a succession of hills and dales, up and down which the treadles have to ascend and descend, according to the exigencies of the design of the fabric. Continuing our metaphor, these treadles may be regarded as travellers who are moving in company to one destination, that being the end of the cloth. There is this important difference, however, they, unlike actual travellers, are fixed to a certain position and mark time merely, whilst the hills and valleys move underneath them, lifting them up and letting them down in exact correspondence. These movements by elevating and depressing the shafts of healds every time a change takes place, form a shed in the warp for the passage of the shuttle. When the cycle of changes has been gone through, the design has been completed, and the operations begin anew. This goes on as long as desired.

The risers and sinkers fitted upon the plates operate the treadles in a positive manner. The treadles carry anti-friction bowls to ease the passage of the risers and sinkers. They transmit their motion through connecting-rods or cords to the levers, which raise and lower the healds in the manner already shown.

This treading motion can be and is commonly used to weave fabrics requiring up to twelve shafts, and by varying the arrangement of the risers and sinkers upon the plates a considerable variety of patterns can be obtained. It is, however, a very cumbrous motion to work, taking a considerable time to pull to pieces and to put together

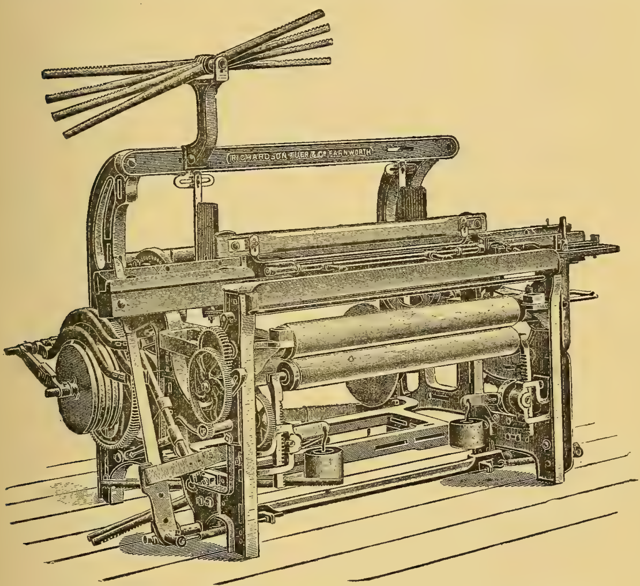


FIG. 120.—FUSTIAN LOOM WITH WOODCROFT TAPPETS.

again for re-arrangement, whilst if a mistake happens to be made in the work it is all to do over again. The task, besides stopping the loom for a considerable time while changes are made, is also a dirty one. When at work it is also slow and exceedingly noisy, adding very greatly to the inevitable clatter of a weaving-shed. Thus it has been dispensed with wherever possible, and is now

retained only for cords, moleskins, heavy velveteens, belt-webbing, hose-pipes, and kindred classes of fabrics.

On the line chosen, namely, that of development from the lower to the higher capacity of the shedding power of the loom, we now come, though somewhat out of time and place, to the draw-loom. A brief notice must suffice as it has disappeared from practical work, superseded by the jacquard.

Persons familiar with the history of weaving know that for the production of decorated fabrics which required something beyond the capacity of the appliances that have been described, there was in concurrent use the draw-loom, a machine that practically gave the weaver individual command, for shedding purposes, of every thread of his warp. Damasks, by which these figure-decorated fabrics have long been known in textile history, are supposed to have been first, or at least, so extensively made in Damascus, as to have derived their name from that city. They were no doubt introduced into this country by ecclesiastics at an early date, and it is supposed that the draw-loom itself came from the same place, brought over by the Crusaders. Improvements in details subsequently occurred, but they were not of great importance until the drawboy machine made its appearance. Who invented this can hardly be said to be definitely known, but the best records discoverable in the English Patent Office would favour the claim of one Joseph Mason, who patented a machine for an equivalent purpose in 1687. This patent was No. 257 of the year named, and was dated October 3rd. Unfortunately no specification was enrolled.

The draw-loom, as an ancient loom of the highest capacity, and the one on which the wondrous fabrics of the olden times were wrought, for the sake of the student deserves a brief description before we come to the consideration of its great successor, the jacquard machine.

In the draw-loom the warp threads were drawn through separate and independent healds or mails, so named be-

cause they carry the threads, the cords of which were passed through the comber board to keep them from entanglement. Next, a number of these, according to requirement, were tied or harnessed to other cords, which thus governed a number, so that when one of the latter cords was pulled several warp threads were controlled, precisely as a coach-driver controlled his horses by the harness, and hence, no doubt, was borrowed the name of harness, from the similarity of the function. The harness cords ascended from the comber board to the pulley box, some height above, whence, after passing through the bottom of the box and over the pulleys, they took a horizontal direction for some distance over and beyond the loom side and were then attached to a staple or bar on a level with them. These horizontal cords were termed the tail of the harness. At their mid-length other cords, termed "the simple," were attached to them. These cords descended to near the ground, where they were secured to a horizontal rod sufficiently long to take the whole. It was upon these that the pattern was arranged. There were other details also, but as they were only to facilitate the operator's getting hold of the "simple" cords, they hardly call for more particular description. This was done in the order of rotation required by the pattern. The cords of the simple were pulled down and raised the corresponding portion of the harness, and its leashes or healds opened the warp in the same order, which was kept open until the requisite portion of the pattern was woven, when the necessary succeeding changes were then made. The working of the simple was the drawboy's task, which was far from being an easy one. The weight of the lingoes, of which there were often thousands, more or less of which he was constantly engaged in lifting, became appreciably burdensome before a day passed over. There was also a great deal of friction to overcome in operating them. No wonder, therefore, that attempts were made to ameliorate this burden.

The first practical improvement that sprang from these efforts was the invention of the drawboy machine. This consisted of an oblong frame about as high as it was long, and about half of the dimension in width. Within this frame was arranged a rocking shaft, connected with a sector picker, which had a lateral traverse the length of the frame. The two sides of the frame were perforated for the reception of the lingoes, and the picker in its passage drew down the lingoes, and through the connections already explained shedded the warp. This appliance gradually came into extensive use, but, though an improvement in many respects, it greatly increased the toil of the weaver's daily task without giving him much compensation in economy, as the master weaver, having to provide it, made a charge for its use not much below the cost of a drawboy. The dawn of the happy days of the weaving industry, in which the employer provides everything, as in the modern factory system, had not then broken upon the weaver's vision, though they were nearing. The invention of the drawboy machine was a distinct advance in the direction of a perfect system of mechanical shedding, and as such deserves this brief reference.

The drawboy in the first instance, and the drawboy machine after him, drew the "simple" cords in regular sequence, according to the plan or design which he had before him, whilst the weaver operated the loom, and put in the weft either straight forward or in a corresponding order, if colours were in requisition. Thus it will be seen was developed the harness of the artist weaver. As experience increased in the use of this harness different systems of grouping the healds thus to be controlled were developed. These were called "ties," or "tie-ups," of which there are a fair number. The simplest and the ones most commonly in use in this country, are those known as the London and Norwich ties, which differ from one another only in the London tie being mounted upon the loom with

its frame parallel to that of the loom, whilst the Norwich one is mounted with its frame transversely to that of the loom.

We have now arrived at the time when the grandest of all the mechanical inventions ever designed for the purpose of warp shedding made its appearance. This is the jacquard machine, which was invented originally as an attachment to the hand-loom and not to the power-loom, which it almost anticipated as a practical working invention of value. Its primary purpose was to relieve the hand-loom weaver of the difficulty he experienced with both the drawboy and the drawboy machine. At that time it is very improbable that its inventor ever contemplated its adoption to the power-loom as a shedding appliance, and much less would he do so to the many other useful purposes in which it is so frequently met with, and giving every satisfaction in these days.

As with many other important inventions there are rival claimants for the honour of being the inventor of this machine, and no doubt strong and important and well-founded arguments have been advanced to prove that the merit ought at least to be divided between Jacquard and some of his predecessors in the field of mechanical science. In the interest of the technical student a short space may be devoted to a review of Jacquard's career.

Joseph Marié Jacquard was a native of the great silk manufacturing city of Lyons, where he was born on July 7th, 1752. His father was a silk weaver, and his mother was also engaged in the trade. Though thus cradled in the weaving industry at the outset of his working career he preferred and adopted bookbinding, and afterwards followed on with type-founding, and subsequent to this he transferred his energies to cutlery manufacturing. Whilst at this occupation the death of his father, who left him a cottage and a silk loom, brought him back to the silk trade. He does not, however, appear to have met with any success, but rather otherwise, as after his

marriage he would seem to have reverted to his earlier industrial pursuits. In 1792 he became involved in the whirl of the Revolution, and in the following year was engaged in the defence of Lyons against the forces of the Convention. It is stated that his son was killed by his side, which caused him to retire from the profession of arms. Previously to this episode of soldiering, in 1790, he had begun to contemplate the feasibility of constructing the machine with which his name has since become identified. The design, however, was probably laid aside during the troublous and distracting times of the progress of the Revolution. When it was resumed we have no knowledge, but in 1804 the machine appears to have been completed, and near the same time was exhibited at the National Exposition, and secured for him the barren reward of a bronze medal, which Jacquard did not know how to turn to account, as he lived before advertising became a fine art. About this time also he seems to have obtained a prize for the invention of a loom for weaving fishing-nets, offered by the English Society of Arts. He got a patent for his shedding machine which seems to have included a right to a premium of £2 for every machine made and sold. About 1804 he returned to Lyons to push his invention. In its introduction, however, he met with the ill-luck of most inventors in those early days, namely, bitter opposition. Its merits having begun to be appreciated they were leading to its extensive adoption, when its opponents gathered in force, denounced both the machine and its parent, tore them from the weaving-rooms in which they had found adoption, and destroyed and publicly burned the fragments in the streets. Even the "Conseil des Prud'hommes," belying its name, condemned both the invention and its author, and he had to fly from the place to save his life, as his great forerunner in the field of textile invention, James Hargreaves, had had to fly from the Blackburn district, the great weaving centre in Lancashire. But, like other destroyers of ma-

chinery, the French could not burn the idea. The machine was reconstructed with improvements in details, and its value having been demonstrated, it was again rapidly adopted in France, and soon spread to other weaving centres of the Continent, and at last found its way into England.

In the meantime Jacquard continued to live on, witnessing the increasing usefulness of his machine, until August 7th, 1834, when he died at Quillins, near Lyons, in the eighty-third year of his age.

It is in his native country that Jacquard's claim to recognition and merit on account of this invention is most contested. M. Marin, a Lyons professor of weaving, exhibited a series of models, showing the development of Jacquard's shedding apparatus from the inventions of earlier mechanicians, namely, M. Bouchon, who, in 1725, is alleged to have employed a band of perforated paper which was pressed by a hand-bar against horizontal wires, and pushed forward those which happened to be opposite blank spaces, whilst the others entering the perforations, similar results followed to those with which we are acquainted to-day. Three years afterwards, in 1728, M. Falcon is said to have improved on this by introducing a chain of cards, and the square prism in common use to-day, and known as the cylinder. No further progress appears to have been made until about 1745, when Vaucanson, a well-known early mechanician and inventor, dispensed with the tail cords of the draw-loom, and made the loom capable of being operated by the weaver alone by placing the perforated paper, or chain of cards, upon the surface of a large pierced cylinder which had a backward and forward traverse each stroke, and which was caused to revolve through a small segment of a circle by means of ratchet work making a movement coincidently with its lateral traverse. The same inventor is said to have introduced the rising and falling griffe, and thus nearly anticipated Jacquard in every detail of his shedding

machine. Whether these allegations are, or are not, true either in whole or part, we are not concerned to inquire. They are made by a Frenchman against a Frenchman, and have, like the most of this class of charges, come too late to be of either advantage or disadvantage to the parties principally concerned. Jacquard is in possession of the reputation of being the inventor, and the Municipality of Lyons has erected a statue to his memory on the spot where it formerly burnt his invention, and has thus satisfied the claims of poetic justice, and there the remainder of the world may be content to let the matter rest. We may add, however, that Dr., afterwards Sir, John Bowring, before a Committee of Parliament in 1831-2, gave particulars of an interview he had had with Jacquard, in which the latter practically admitted his indebtedness to Vaucanson, so that this precludes to a considerable extent any charge of ingratitude that might be alleged in advancing Vaucanson's claim.

Jacquard's invention was rather late in finding its way into England, probably owing to the almost constant warfare that prevailed until after the battle of Waterloo. The first Englishman who appears to have seen it was Mr. W. Hale, a Spitalfields silk manufacturer, who made known his discovery to a Mr. Stephen Wilson, also in the silk trade. After some time this gentleman went over to France, procured a machine, and on his return seems to have invented a card-cutting machine, and to have patented the two together (No. 4543, March 8th, 1821). Jacquard's machine was soon afterwards heard of in Coventry, Macclesfield, Manchester, Halifax, and other places, and no doubt very quickly met with general adoption.

We have given this brief sketch of Joseph Marié Jacquard and his invention, because of the great influence it has had upon the weaving art, and the numerous purposes to which it has been adapted outside that for which he originally designed it. Whether in this instance he

was the inventor, or only an adapter of other people's ideas is not very material, as, like Arkwright, he is certainly entitled to the credit of making practicable devices that, up to the time he took them in hand, were failures.

The Jacquard Machine.

The jacquard shedding apparatus, the story of the invention of which has just been narrated, will now be described in detail, so that its construction and operation may be correctly understood. The inventor's name has long been transferred to the machine, therefore, in consonance with this convenient custom, and for the sake of brevity, it will be called by this designation.

Of jacquards there are a number of types, each varying in capacity from very small ones containing about 100 needles to large ones ranging up to 2,000 needles. Of course were larger than these required there would be no difficulty in making them.

The number of needles expresses the size or capability of the machine: thus there are 400^s, 800^s, and 1,200^s machines, and intermediate sizes. Those usually employed in the trade are regarded as standard sizes, and departures from them are looked upon as specialities. But whatever be the size or type of the machine, its chief parts are essentially the same, however modified for adaptation to particular requirements.

The accompanying illustration, fig. 121, represents a standard make and type of jacquard, containing 400 needles and one cylinder, and arranged for what is termed the double lift: that is, it is a 400 needle machine, but instead of having only 400 hooks it has 800 or two to each needle, and also two griffes instead of one. This machine is extensively used in weaving cotton goods and all fabrics in which high speed is desirable, as it can be worked to shed for 200 picks per minute, though not more than 160 to 180 are recommended.

The jacquard, it will be seen from the illustration, consists of an iron frame which stands about eighteen inches high, its lateral dimensions varying according to the number of hooks and needles it contains. In this frame are mounted the working parts which are actuated through various connecting rods, shafts, and levers, from the

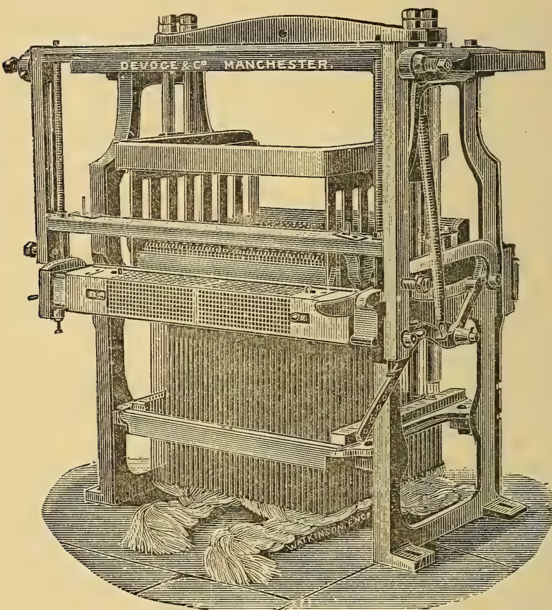


FIG. 121.—DOUBLE-LIFT JACQUARD 400s, ONE CYLINDER.

crank and second motion shafts of the loom. The cords seen upon the ground of the illustration are termed the neck-bands or neck-cords. These are looped upon the tail-pieces of the hooks of the jacquard, otherwise their lower extremities. They are then passed downward, occasionally through a perforated board at the bottom of the frame

called the bottom board. In modern makes of jacquards this board, on which the hooks rested when out of action, has been superseded by some bars or blades, termed hook rests. This avoids the wear and tear of the neck cords which took place with the boards. The cords are attached by a slip-knot to the leashes or harness, as shown previously in fig. 106, p. 151. The slip-knot is to permit of a perfectly level adjustment being made of the harness-mails.

The following are the principal parts of the jacquard:

1st. The hooks. The hook shown in fig. 122 is made out of wire of about 16^s gauge. The wire is first cut into lengths and made perfectly straight in a machine specially designed for the work. It is then bent in the shape shown in the illustration. The top is formed into a hook to admit of its being lifted by the griffe. The bottom, A, is bent for the reception of the neck-cord, and is turned up a good distance to prevent all risk of its slipping off. The top of the end thus turned up is formed into a hook as shown, for the purpose of resting the hook upon the bar, B, when out of action. This bar is called the hook-rest.

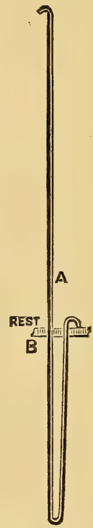


FIG. 122.

2nd. The needles. These govern the hooks. The hooks are normally in a position to be actuated by the griffe, and would be lifted every time it ascended were it not for the control exercised over them by the needles which leave them in or put them out of action as required. In the illustration, fig. 123, three kinds of needles are shown: *a* represents the needle as used in a single-lift jacquard; it has a loop or eyelet formed in its length through which the shaft of the hook passes. In *b* is shown the kind used in a double-lift machine; this has two bends, not eyelets as before, to enable it to operate two hooks, there being, as stated

before, two hooks to each needle in the double-lift jacquard. In *c* is delineated the kind used in a double-cylinder machine; this contains only one bend. All jacquard needles are bent at one end in the manner shown in order to form a butt-end for impact against the springs in the spring-box.

FIG. 123.

3rd. The griffes, fig. 124. In a single-lift machine there is one griffe; in a double-lift there are two as shown here. The griffe in a jacquard loom is the equivalent of the tappet in a plain loom, as it forms the warp-shed. A more rational name for it, at least in English, would be the hook-lifter. It has an ascending and descending movement. It is,

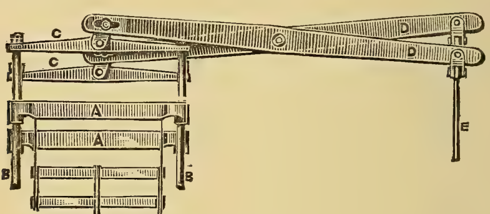


FIG. 124.

roughly speaking, a square frame, A, mounted upon the vertical cylindrical rods B, which slide in appropriate ears or lugs cast upon the frame. Fig. 124 shows them in detail and detached from the frame; in fig. 121 they are seen with their connections in their working position.

4th. The batten, A, fig. 125. The batten is somewhat like the lathe or lay of the old hand-loom both in its construction, action, and function. It is composed of two arms and the block called the cylinder. It has a semi-oscillating movement which would be best described by

saying that it is equivalent to the half of the movement made by a clock pendulum. It derives its name from its function of beating back the needles and so putting the hooks out of action as required. It is shown in the front of fig. 121 with its cylinder, the horizontal block with the numerous small perforations. This block is not solid but hollow, being built up of four perforated slabs. The batten is a principal feature of the machine.

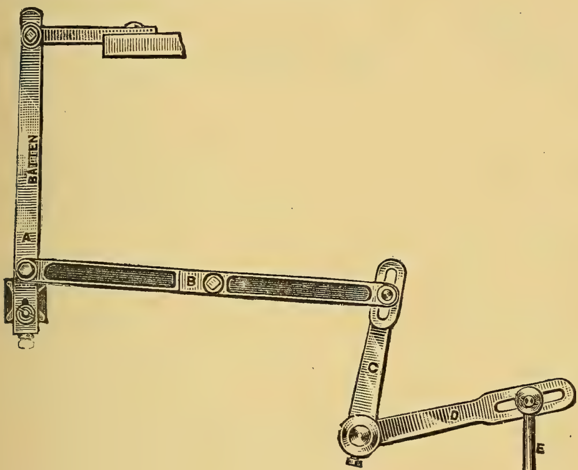


FIG. 125.

5th. The cylinder, fig. 126. This, as just observed, is a part of the batten. Strictly speaking, it is a prism of four sides. Its function is to press back the needles which govern the hooks and so put them out of action when their threads are not required to be lifted for forming the shed. It has four faces, as will be seen from the sectional view in fig. 126. It is so actuated as to make one-fourth of a revolution with every pick made by the loom, thus bringing its different faces in successive order into contact with the needles. If the faces of this cylinder were without the

perforations shown, A A′, at each impact every needle in the jacquard would be pressed back and every hook thrown out of action, not a single thread would be lifted, and consequently no shed would be formed. It becomes, therefore, a necessity to make the small circular holes in it in order that the needle-ends may enter, and the hooks which they control may not be pushed back when they are required to be left in operation. As this is in turn needed with all the warp threads it becomes necessary that the faces of

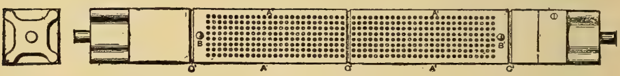


FIG. 126

the cylinder shall have as many holes as there are hooks in the machine. This being the case, we are confronted with another important fact, namely, that if left in this condition the face of the cylinder, when carried by the batten into impact with the needles, would receive the point of every needle into its corresponding hole and thus everyone would be left in position to be lifted, and would be lifted by the griffe in its ascent. Every thread in the warp would then be brought up with them, and thus again

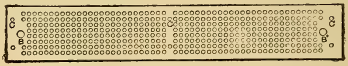


FIG. 127.

there would be no shed for the passage of the shuttle. In the first instance given the shuttle would pass over every thread, in this it would pass under them. It will now have become obvious that something more is required which shall discriminate or select the hooks that shall be lifted and those which shall not lift. This is:

6th. The card, fig. 127, which is so called because it is composed of cardboard specially made for this purpose. The card might appropriately be termed the hook-selector, for that is its function. It does this by intervening between the

cylinder and the needle-points, blocking the entrance to the cylinder-holes, and causing to be pushed back those needles whose hooks are not essential to form any particular shed, and leaving undisturbed in their position those required to make it. This is accomplished by the cards being perforated according to the requirements of the design to be woven. If a blank or unperforated card were placed between the cylinder and the needles it would have the same result as we have seen would be the case in the event of the cylinder-face being without perforations: every hook would be thrown out of action and no portion of the warp would be lifted. Similarly, if a card had as many perforations as there were needles every hook would be left in position to be lifted and the whole warp would be raised. Therefore, when it is desired to raise any given thread, a perforation is made for the needle of the hook carrying it, the needle-end passing through the hole in the card and into that of the cylinder, thus leaving its hook to be lifted. As the lifting of the warp threads varies with every pick the loom makes, to accomplish this the cards require to be perforated in like varied manner. Thus it comes to pass that a different and special card is needed for every pick required to complete a textile design, excepting, and this is sometimes an important exception, one card can be repeated many times. When this is the case an arrangement is brought into action by which the revolution of the cylinder is arrested and the repetition is accomplished. The "round" of a design, or the number of picks required to complete it necessarily varies; in small designs a few hundreds suffice, whilst in large and elaborate ones the number will run into thousands.

To keep cards in consecutive and proper order they are tied or laced together. Let the reader revert for a moment to the illustration of the cylinder, fig. 126. The two central sections, A A′, form the face for the reception of the card, and its other three faces are exact replicas. The two larger circles, B B′, at the outer ends of the cylinder-

face represent the card-pegs which, when the card comes upon the cylinder, enter the holes indicated by the corresponding circles B and B′ in the card, fig. 127. These pegs are sometimes simply solid, but in modern practice they are generally mounted upon small helical springs, in order that in the event of a card getting displaced and missing presenting its hole from any cause, which sometimes happens, the pegs may yield and sink into the the cylinder until it passes, rather than break or otherwise damage it. It is to be preferred that cylinders should be furnished with spring-pegs rather than not. The cards are laced together generally at three places: each end and in the middle. This is done by means of a fine, strong hemp-twine which is passed through the holes marked C, fig. 127, in such a manner as that, whilst leaving the cards perfectly pliable and easy to fold backward or forward, they shall be held without the slightest chance of slipping from their proper positions. The grooves, C′, in the cylinder, fig. 126, are cut for the reception of these cords, so that the card shall not be prevented from lying close to the cylinder-face. The remainder of the perforations in the card are for the needles.

7th. The hooks and needles. In fig. 128 are shown eight hooks, A, and needles, B, arranged as when mounted in the jacquard for work. As shown here the hooks repose, when out of action, upon the hook-rest shown at C. Ascending from this rest it will be seen that the hooks are received into the eyelets or the bent parts of the needles, beyond which they project a short distance, and terminate in the hooks, D, at their head, by which they are lifted by the griffe-bars, blades, or knives, E, as these are variously called in different localities. It is from these hooks at the top that the name is derived. The griffe-blades are shown in section. The horizontal wires, B, are the needles, which have already been sufficiently described.

The function of the cylinder, it has already been explained, is by means of the needles to push out of action for

the moment those hooks whose services are not required, and that of the card to discriminate which are these. Of the series of eight needles and hooks shown, five are represented

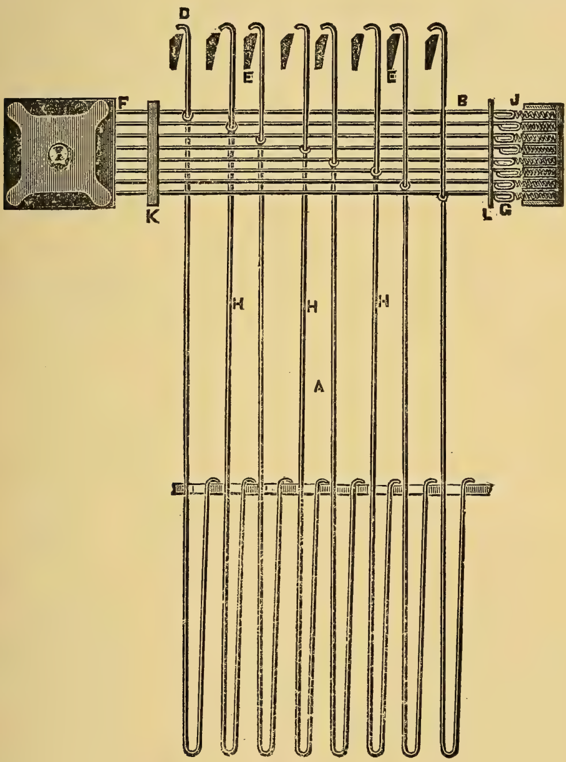


FIG. 128.

as in action, and three, marked H, as pushed out. The ends, F, of the latter's needles presenting themselves before a blank space in the card, in the swing of the batten are pushed back, their opposite ends, G, compressing the small

helical springs, J, of which each needle has its own. The needles thus pushed back deflect their respective hooks so far from the perpendicular that they get clear of the line of movement along which the griffe-knives, E, ascend. They are therefore just left out of action. As, however, they may be wanted to rise in the next shed it is necessary they should immediately be returned with perfect certainty to the position within range of the action of the griffe. In the meantime the batten has swung away in order to admit of the cylinder making another quarter-turn, and bringing a new card into operation. This action removes the

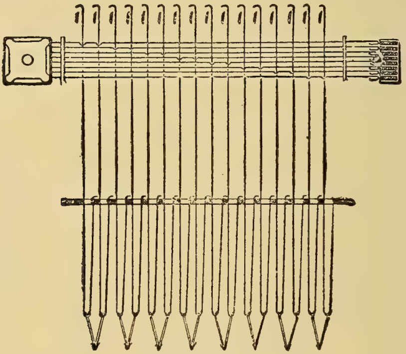


FIG. 129.

pressure from the needles and permits the springs to instantly return them to their first position ready for duty if called upon. If they should not be wanted they are again pressed back and are again returned in a similar manner. In fig. 129 is shown the combination of hooks and needles as required for a double-lift machine with a single cylinder. In this arrangement, as before observed, the needles have two bends to enable them to operate two hooks each. Fig. 130 is a similar diagram, illustrating the arrangement of the hooks and needles in a double-cylinder machine.

8th. The needle-board and lintel-frame. It will be observed that the needles are arranged horizontally in fig. 128. This position is requisite to enable them to be presented with their points directly opposite their respective holes in the cylinder-face, and at the opposite end to the springs, so that they may not work in any way improperly, be deranged, or miss performing their duty. At the end nearest the cylinder, therefore, there is arranged a perforated board, K, about half an inch thick and set on its edge. It is of the same dimensions as the face of the

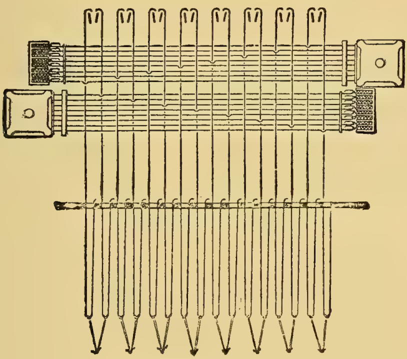


FIG. 130.

cylinder, and has a perforation for every needle. This board is termed the needle-board. On the opposite side, outside the last line of hooks, is a wire-grid or frame, L, composed of vertical wires set with a small space between them and crossed with a horizontal wire or two, thus constituting small square spaces through which, in mounting them, the ends of the needles are passed and pushed home, leaving the looped ends supported in the wire frame as the points are in the needle-board. This is termed the lintel-frame.

9th. The spring-box, fig. 131. There still remains the

springs, J, to be described. It has been shown what their function is. They are composed of fine brass wire to prevent destruction from oxidation. There is one for each needle. The number therefore is considerable. In order to maintain them in a proper position in relation to their work they are arranged in a box composed of a block of wood in which the requisite number of holes are bored for their reception. These holes go through the block but have a vertical wire pin let down through their centre at the back, which prevents the spring being pushed out, and against which it is compressed. Should the spring become weak or break, by withdrawing the pin it can be easily replaced. The box is fixed horizontally in the frame in such a position that, when the needles are pushed back by the batten, their bent ends, G, shall compress the springs so

FIG. 131.

much that, when the pressure is removed, the springs shall return the needles to their first position as previously shown. This box is termed the spring-box.

The preceding description will have made clear to the reader the function of the jacquard as an adjunct to the loom, its construction and method of operation. The example described and illustrated represents the one in probably the most common use. For the sake of the student we may, however, illustrate a few more types. They need very little further description.

In fig. 132 is shown a single-lift jacquard of 400 needles and the swing batten as before. This term is used to distinguish this method of operation from the horizontal motion. This machine is used for weaving silk, cotton, and other goods where a high speed is not required, as it is not adapted to work at more than 120 picks per minute. It will be observed that it has only one cylinder.

A machine of very high working capacity is shown in fig. 133, which illustrates a double machine, 400^s, having two cylinders and batten actuated by the swing motion. This machine is used for weaving cotton, linen, and other fabrics that will permit of being worked at a very high speed; it is capable of shedding 220 turns per minute, though from 180 to 200 is what is recommended. As the cylinders work alternatively it permits of this high speed

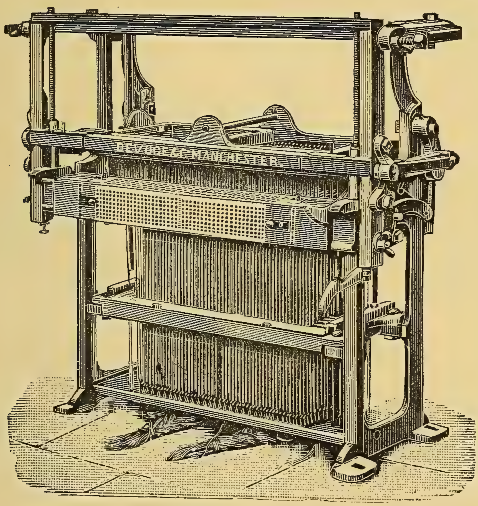


FIG. 132.

with less vibration than when a single-cylinder machine is used.

Fig. 134 shows another double machine of the same capacity, and for the same purposes as the last one. In this the battens, instead of being swung from the frame as in the preceding instances, have a horizontal reciprocal sliding motion, termed the horizontal motion.

In fig. 135 is shown a machine of still greater capacity.

This is a compound machine, with two cylinders, and adapted to weave cross borders, that is, to put borders into the fabric at specified distances according to requirement. It can be arranged to work as a double machine, with the cylinders working alternatively; or it can at option be worked as an 800-needle machine, single lift, in

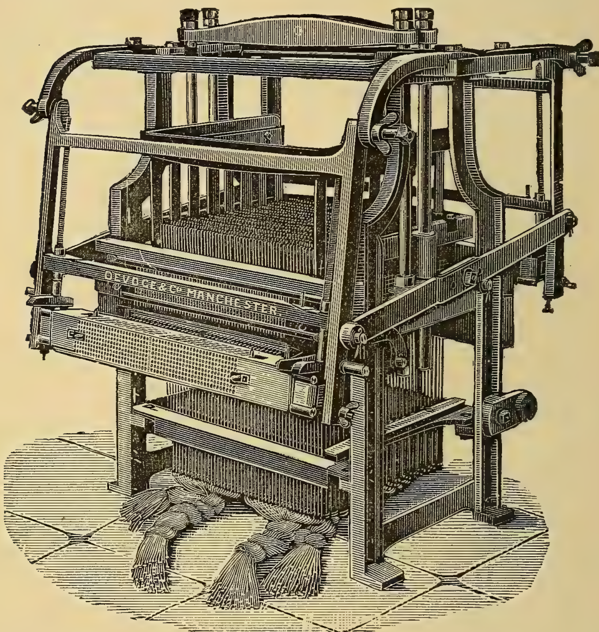


FIG. 133.

which case the cylinders are worked together. When used as a cross-border machine, the cross-border cards are put upon one cylinder, and the middle or ground cards upon the other. The cylinders can be thrown out of or brought into action according to requirement by the attendant weaver, or by automatic action as desired.

One more illustration will fully serve all necessities. Fig. 136 shows a patent leno machine, a recent invention. This is a valuable machine where leno or lace effects are wanted. It may, therefore, be described at more length. The leno or gauze weave has been sufficiently explained in a previous chapter, and therefore need not be repeated

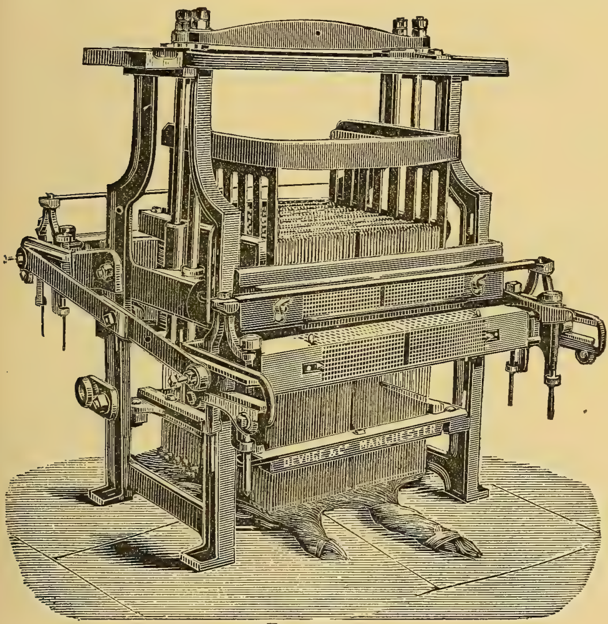


FIG. 134.

here. The machine, of which the illustration is a representation, is used for weaving leno or gauze fabrics with 4 threads per dent of the reed. By casting out the necessary hooks it can also be used with 3 threads per dent. The machine has 612 hooks, 51 rows, 12 in a row, besides selvage holes. Of these, 100 hooks are allotted to the

doup harness; 400 for the middle or figure harness; and 100 for the warp-easing or slackening harness. This disposes of 600 hooks and leaves a spare row. With these 600 hooks it is only necessary to use 500 needles, as those allotted to actuate the doup hooks also each operate a warp-slackening hook. The double duty these needles

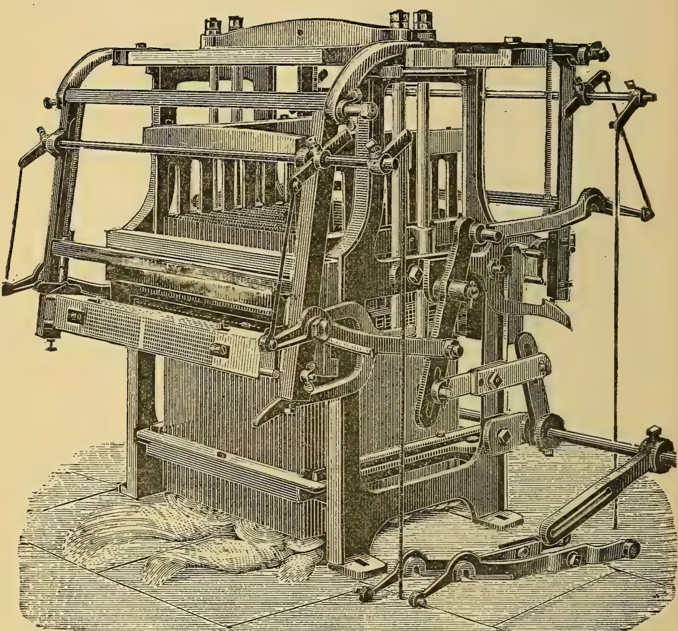


FIG. 135.

perform is a great advantage, because a doup warp thread can never be shedded without at the same time being slackened to permit it to make its three-quarter twist around its fellow thread. Thus both strain upon the warp and the doup harness is perfectly avoided. Each dent of the doup and the slackening harness is worked indepen-

dently, so that several styles or patterns of leno can be made in the same fabric if desired. There are two griffes used in this machine, the original one to lift the doup and figuring harness, and a small one to lift the slackening harness. The first is lifted by the ordinary lever arrange-

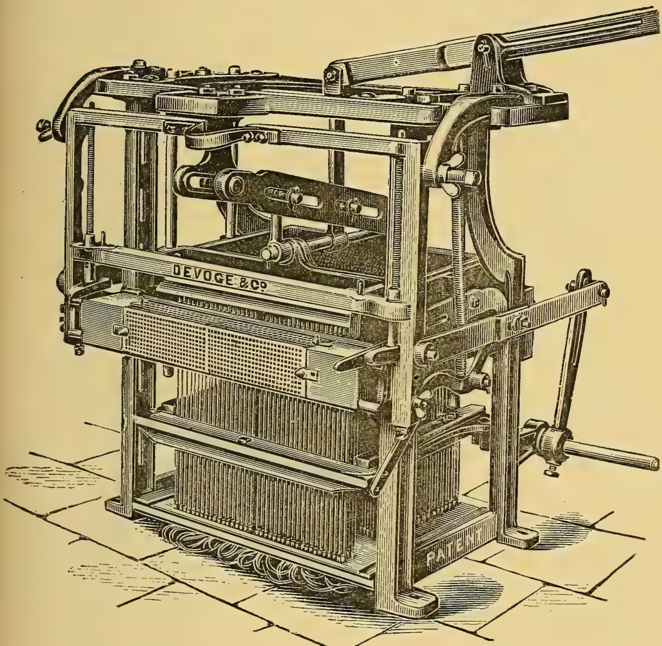


FIG. 136.

ment, and an additional lever, the slotted one shown in the middle of the upper part of the frame, arranged at right angles to the large lever, lifts the small griffe. Being constructed with an adjustable fulcrum, a considerable variation can be made in the lift according to requirement. For instance, suppose that the lift of the large

griffe is 4 inches, that of the small one can be set at any point, $1\frac{5}{8}$ and $2\frac{3}{8}$ inches inclusive, so that as great a range of variation is provided for as is ever likely to be required. The slackening griffe is arranged to commence lifting slightly in advance of the upward movement of the large griffe, in order to slacken the leno portion of the warp in advance of the lifting of the doups, and thus to prevent either friction or strain. By this arrangement the wear and tear of both yarn and healds is greatly diminished. The machine is operated in the same manner as ordinary single-lift machines, namely, by the lever shown on the top of the illustration, which is connected by crank or eccentric to the loom shaft. It is fitted with a simple and effective reversing motion for the cylinder.

The machine is made with what are termed hooked hooks, which permit any or all of the three harnesses to be taken off. By removing the doup and slackening harness, and using a 400^s cylinder, this jacquard is converted into a 400^s single-lift machine for weaving ordinary fabrics, and of a range of power commensurate with the ordinary jacquard.

Until quite recently, however, one considerable defect in the method of actuating jacquards remained without remedy. It will have been observed throughout all the preceding description that the jacquard griffes have been lifted by means of horizontal levers which have their fulcrum some distance away from the centres of the jacquard. The consequence is that as the ends of these levers in lifting the griffes and returning them to their position pass through a small arc of a circle, and instead of lifting them vertically, pull them against their guide bearings inducing friction, wear and tear, and the expenditure of considerable power in order to overcome it. These defects having engaged the attention of Mr. Brierley, manager for Messrs. Swainson and Birley, Preston, he has endeavoured to remedy them and has succeeded. His improvement is illustrated herewith, fig. 137, and, as will

be seen, the horizontal levers are dispensed with, a rack and pinion arrangement taking their place. The machine is actuated as before from the tappet shaft of the loom, one end of which carries a crank disc to which the connecting rod is attached. The top of this rod is secured to an adjustable link which is connected with the lower end

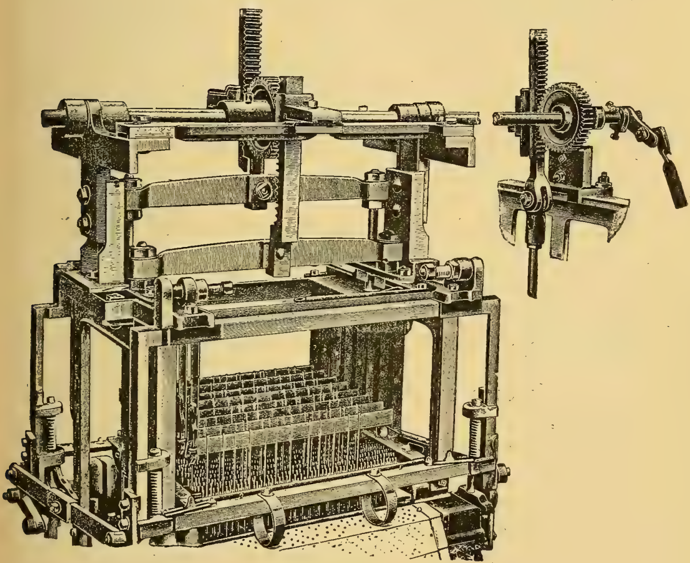


FIG. 137.

of a vertically sliding bar, the upper portion of which constitutes a rack. Into this rack gears a pinion carried upon the end of a shaft extending across the top of the jacquard frame and supported upon it. Over the middle of the jacquard frame, upon this shaft, is another pinion which gears into the two racks as shown, and through them operates the jacquard.

It will be seen that the lift thus obtained is a perfectly vertical one, and that connection between the two griffes constitutes them each a counterpoise of the other, which results in a much easier drive. The outside rack and connecting rod find their counterpoise in the action of the spiral spring shown.

The result may be summed up in a few sentences. The driving, with this new arrangement, absorbs much less power than under the old form; wear and tear is greatly diminished; all the destructive vibration through the loom is obviated, by which the breakage of the warp yarn is diminished; and, not least, a much higher speed can be obtained than from the old forms. These are claims that ought to ensure the attention of manufacturers using these machines.

The jacquard having now been described in such a manner as we trust will render its principle, construction, and action perfectly clear to the simplest understanding, we may pass to a brief description of some subsequent developments, chiefly modifications and simplifications, of the jacquard for more limited ranges of work. These are generally known as dobbies, which are in reality small jacquards.

The changes and improvements in the jacquard, which finally eventuated in the production of the dobby, began to appear comparatively soon after the jacquard had been somewhat extensively adopted. One of the first of these, and the first to which we have found the name of the dobby attached, was an invention by Mr. S. Denn, of Spitalfields. This was an important improvement, as it accelerated the shedding operation, and led the way to the next improvement—the introduction of the double-action principle in an invention patented in 1849 by Mr. Alfred Barlow. This also was a considerable step in advance, but showed some defects, which were subsequently obviated by improvements made in 1855 and 1870. About 1858 a German invention on the same lines was introduced into

Lancashire, and a considerable number of machines were made by the Blackburn loom makers during the succeeding three or four years when the introduction of the manufacture of bordered dhootie cloths for India took place. In 1867 the dobby assumed a more perfectly developed type as a shedding appliance, in the invention of the Keighley dobby by Messrs. Hattersley and Smith, than had been seen before. This dobby, with some subsequent improvements,

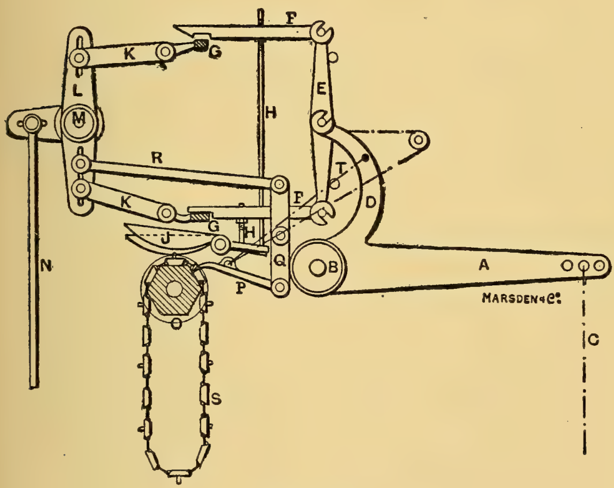


FIG. 138.

has held a strong position to this day. Its construction is shown in the accompanying illustration, fig. 138, which also incorporates the improvement patented by Mr. J. Eccles, of Preston, in 1877. It is on the double-action principle, one cylinder carrying two sets of cards instead of two cylinders with a set of cards each. The illustration shows the working details divested of the frame for the sake of clearness. Mr. Eccles's improvement consisted in

adapting it to work intermittently, so as to make cross-bordered dhooties, and in the intervals between their insertion to permit the loom to weave plain cloth. The illustration shows a side elevation. The front crank lever, A, is one of a series mounted upon the shaft, B, which is supported upon the machine frame. The long arms of these levers are connected by cords, C, to the healds, the bent arm, D, being connected to a vertical rocking-bar, E. This bar is attached to two hooks or catches, F F, arranged horizontally. These catches engage with the knives, or lifting bars, G G, when they are not held out of contact by the vertical rods, H H, which are connected with the weighted levers, J. The knives with which the hooks engage are carried upon and operated by the projections, K, from the compound lever, L, carried upon a shaft, M, resting upon the frame. The short arm of this lever is connected by the rod, N, to a crank carried upon the tappet shaft of the loom, and by this means an oscillatory motion is imparted to it. The cylinder, O, is a hexagon, and is actuated by the pawl, P, carried upon the lower arm of the vertical lever, Q. This lever, through the connecting rod, R, being actuated by the oscillating lever, L. Upon the cylinder there is shown in side view an endless chain of lags, S, as they are termed, these being strips of wood, each perforated with a number of holes for the reception of pegs, which are inserted in such a manner as by their action to produce the pattern required. These pegged lags are the equivalents of the cards in the jacquard machines, and if it were thought desirable could be substituted by cards. As the chain travels around the cylinder the projecting pegs upon the lags are brought under and lift the levers, J, which through their connections raise the hooks out of action. This it will be seen is the function of the cards in the jacquard.

As we have described this dobby up to this point it is as invented by Messrs. Hattersley and Smith, Keighley. In Mr. Eccles's improvement, the first bent lever of the

series, the one marked A, is diverted from the purpose we have described, and is arranged to automatically arrest the operation of the dobby, and permit the loom to proceed in the weaving of plain cloth. It accomplishes this by being made to lift the pawl, P, from its gearing with the ratchet-wheel upon the cylinder by means of the connection, T, shown between the pawl and the bent arm of the lever, A. This at once arrests the action of the dobby, which remains inactive until its services are further required.

There are several types of dobbies, which, however, differ more in details than principle. There are single lifts and double lifts, and different methods of operating them. Some have the healds drawn down by springs, and others by jacks or levers. Taken all round, however, these differences are only different ways to the attainment of the same results. Fig. 139 shows a loom mounted with a dobby and its connection with the loom.

In this realm of the textile arts, there has, however, recently appeared a most remarkable invention in the shape of a dobby of exhaustless capacity of pattern variation, and that without the entailment of additional cost upon the first expenditure upon the machine to produce them. As it fell to the duty of the writer to carefully examine and describe this invention, upon its introduction from Germany, he cannot do better than quote from "The Textile Mercury" the article in which this was done, and which appeared in that journal on October 17th, 1891.

This novel machine has been termed by its sole English makers, Messrs. Robert Hall and Sons, Hope Foundry, Bury, the patent cardless, automatic, cross-border, combination dobby. The following is the article referred to:

"That the textile arts are very ancient admits of no dispute. It is almost equally certain that ornamental weaving was a very early development of those arts. The numerous references in ancient and classic writers to ornamental fabrics prove this beyond all question. It is

not, however, until mediæval times are approached that existing divisions of the art begin to be recognized. Amongst the most permanent styles of the present day are those known as diapers and damasks. These come into view in this country about the thirteenth century. It is very probable that they are of much older date in their origin than the time mentioned, as the latter have generally been supposed to have derived their name from Damascus, which was famous in ancient times for its textile manufactures. In an English romance of the thirteenth century, entitled 'The Squire of Low Degree,' we read of

> "'Damask white and azure blewe
> Well diapered with lilies new.'

The origin of diaper is more a matter of dispute, some affirming that it is derived from the name of the city of Ypres, thus cloth de Ypres, afterwards contracted into the form we now know. Others contend that it is traceable to the Italian word *diaspro*, the jasper, which it is supposed to resemble from its shifting lights. Though entertaining, these are points which must be left to antiquarians.

"Whatever may have been the material in which these cloths were originally made, the terms long ago came to mean the character of the weave, and thus we now have linen and cotton diapers, silk and linen damasks, and practically both these weaves are one. Diaper generally signifies a cloth covered with geometrical figures, scroll or lattice work, small flowers and other like devices. Damasks have larger and more elaborate patterns. This description roughly defines the character of these kindred types of textile fabrics.

"The means employed to produce these figured fabrics in ancient times have not come down to us, but from late mediæval times it appears to have been the draw loom. After this the jacquard machine came into use, and subsequently its modification the dobby, the latter for the

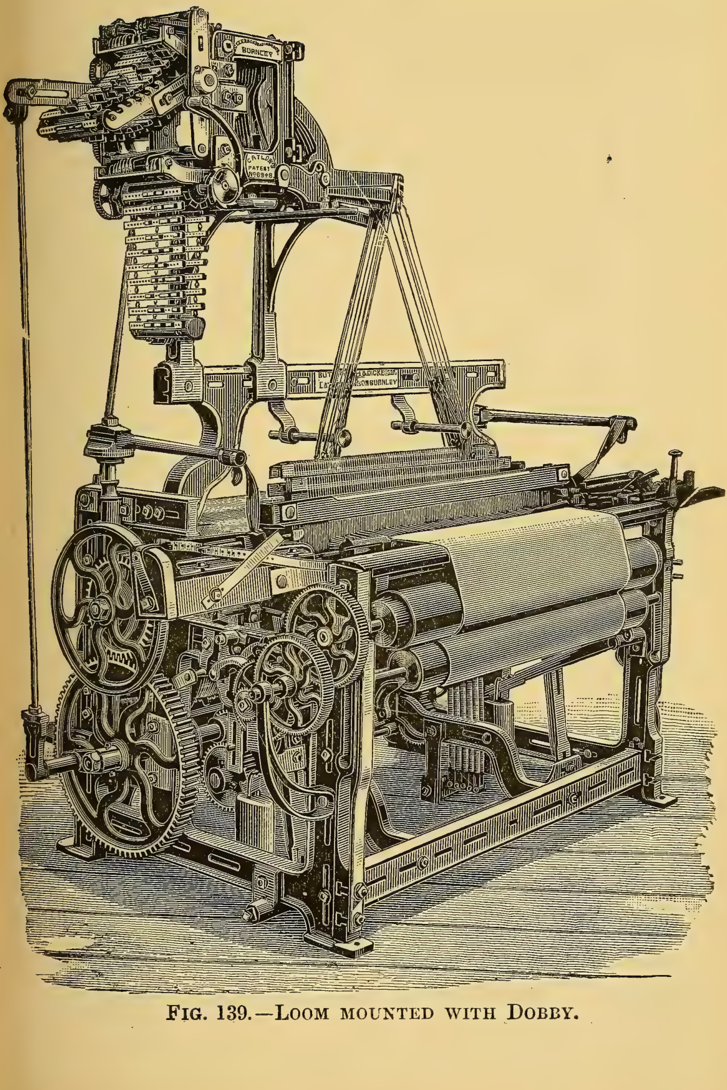


FIG. 139.—LOOM MOUNTED WITH DOBBY.

smaller and simpler diaper patterns mostly. Several other, now disused, appliances intervened. In damasks, however, the jacquard continued to prevail, notwithstanding its great drawback in the shape of cost for cards, etc. There has for a long time now been a steady and continuous movement, endeavouring to diminish this item, which has been attended with a great degree of success, in the invention of repeating motions by which the number of cards required has been greatly reduced in both diapers and damasks. Still there has been room for further advancement, and now we have to record and describe an invention that, so far as diapers go, will dispense with cards altogether.

"The invention under notice removes this great obstacle out of the way by reducing the cost to a point not worth mentioning, by providing the manufacturer with an appliance by which he can produce an innumerable quantity of patterns at one first cost of a few shillings, where by all other known appliances it would be hundreds, indeed we may write thousands, of pounds in the matter of cards alone. The dobby we now introduce to the notice of our readers will weave a large bordered serviette or table-cloth, with a cross border, automatically and absolutely without the aid of cards. The manner in which this is accomplished is as follows: All diaper patterns, such as we see in ordinary linen table-cloths, serviettes, and kindred articles, are combinations of four-shaft twills or five-shaft satins, and the various patterns are formed by floating the warp threads in one position, whilst the weft threads are depressed, and *vice versâ*, this being done in a certain well-defined order that gives the desired patterns. In this invention the needles are arranged in sections of four or five, as the case may be, and each set is raised or lowered, according to the requirements of the pattern. When they are raised, the weft is thrown upon the surface, and when they are lowered the weft is depressed, and the warp brought up. This result is obtained by the cylinder

faces having two rows of holes, one arranged for warp effects, and the other for those obtained by the weft. The cylinder is constructed with as many faces as there are picks to the round; if a four-shaft twill, there are four faces; if a five-shaft satin, there will be five faces. The needles actuate the hooks of the dobby, and raise the healds in the ordinary way. The needles are raised and lowered by small pattern chains, composed of high and low links. These links act upon levers fixed to slides, which have holes drilled in them so as to form guides to the ends of a set of needles. One link in the chain controls the needles for one revolution of the cylinder, and thus puts in four or five picks, as the case may be. By this arrangement the number of links is reduced one-fourth or one-fifth of the number of cards that would be required with ordinary arrangements. But even with this reduction, the chain composed of these links would need to be of great length in order to make a long serviette or table-cloth with cross-border, and do it automatically. But here, again, the ingenuity of the inventor has served him well, for when one pattern has been completed, by an ingenious device the movement of the chain is reversed. By repetitions of these movements the entire centre of a serviette or table-cloth, no matter how long, can be obtained from a few links of the chain. We now come to the cross-border, in making which the inventor has adroitly availed himself of the reversing principle just noted. To the portion of the pattern chain that forms the centre of the fabric is attached a second part, the whole forming an endless chain, though it is not called upon to make a complete traverse. The second part of the chain is arranged to form the cross-border. When the centre part has been completed this border chain comes into action and controls the working of the healds until the border is made. This completed, and the marginal parts woven, a reversing motion sets the border chain upon its return movement, during which the com-

mencing border of the next serviette or table-cloth is woven. These chains are carried upon a barrel. Thus, it will be seen, these pattern chains are reduced to the smallest possible minimum. The invention is shown in fig. 140.

"The cylinder is actuated in the ordinary manner by a

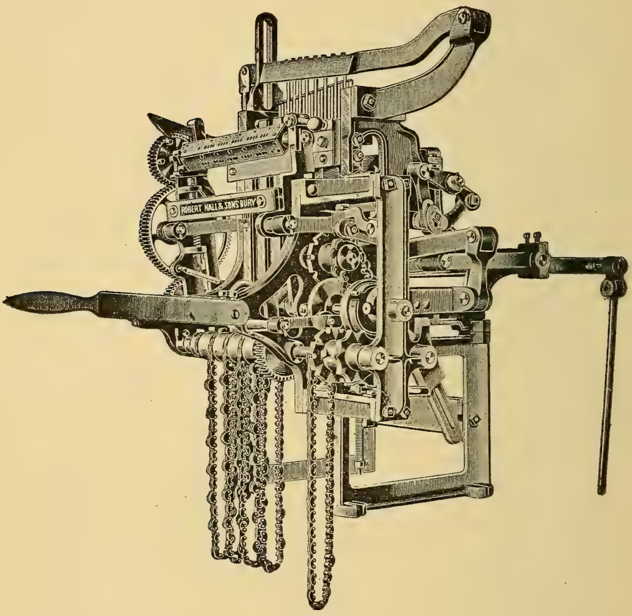


FIG. 140.

peg wheel and catch, and by a wheel on its axis communicates motion through a carrier wheel to a chain barrel in such a regulated manner that the barrel moves the chain one link for every complete revolution of the cylinder. This is done by means of a peg or ring wheel acting upon a star wheel, carried upon the shaft of the chain barrel.

The reverse movement of the pattern chain is obtained by means of another chain, which may be termed a governing chain, carried upon the same shaft as the chain barrel. When a high or tappet link occurs in this chain, it acts through a lever and clutch upon a peg wheel, placing it in gear with another star wheel, which controls another chain, called the reversing chain, and moves it forward one link. If the link succeeding the one moved forward is a duplicate of the one sent on, no reversal takes place; but if it is either a higher or a lower one, then the pattern chains are caused to reverse their movement by the operation of a lever acting on a clutch, which controls the movements of a double peg wheel that by this action is taken out of direct gear with the pattern chain barrel, and put into gear indirectly with it through a pair of spur wheels. We have now followed the mechanical construction of this remarkable invention as far as can be done with clearness and interest without the aid of numerous and elaborate diagrams, and will now invite attention to its capacity in the production of patterns.

"In order to show what the inventor has achieved, we may observe that to make a serviette of ordinary length automatically, about 1,000 punched cards are required, and for a table-cloth, from 2,500 to a much larger figure, depending upon its size. And these quantities of cards would be necessary for every separate pattern, whereas by this machine only four or five small endless chains, about sixteen inches long, are required. These chains will not cost more than 1*s.* 6*d.* each, or 7*s.* 6*d.* for a set of five, and they are, of course, supplied with the dobby itself, and will never need renewing.

"The wonderful capacity of the machine is discovered in the use the inventor has made of these chains. The series are numbered consecutively, 1, 2, 3, 4, 5, and the inventor manipulates these as the ringers in a church-steeple do a peal of bells. By, as it were, ringing the changes upon them he obtains the most surprising kaleidoscopic effects

in the 120 patterns that can be produced from the first arrangement without altering the positions of the links in the chains, the only change required being the alteration of the position of the chain, which can be made from one pattern to another in a single minute, and without cost. In the ordinary arrangements, in which cards are used, the change would require several hours to make, and entail a great expense. Take the case of the range of patterns, 120 in number, that can be produced from a primary pattern, and all beautiful and varying as the figures in a kaleidoscope: the punched cards of these alone would cost £300, the blank cards themselves costing £1 per 1,000.

"But this is far from exhausting the pattern-producing capacity of the invention. We see no reason why one, two, three, or four more chains should not be introduced, in which case, from every primary pattern for which the chains were first arranged, the astonishing number of 362,880 patterns could be evolved. As the primary patterns could be varied as often as desired, it will be clear that the variety obtainable, and this practically at no expense, would run into many millions. We question, however, whether there is not an illimitable field even beyond this, which is yet unexplored. All these come out of the first arrangement of the pattern chains, in which the tappet links are placed in a horizontal line. By ringing the changes on the positions of these links, it is probable that an incalculable number of further variations could be obtained. But, as we have said, this is yet an unexplored field, which must therefore be left with this suggestive conjecture.

"We invite the attention of all classes of textile manufacturers to this invention, which we believe to be perfectly unique, and of inestimable value to them. It opens new realms of design to every one of them, which they can explore at quite a nominal expenditure, a fact that will be more likely to command their attention than any

other quality we can name. The linen, cotton, silk, worsted, and woollen trades, will, we believe, find it of the

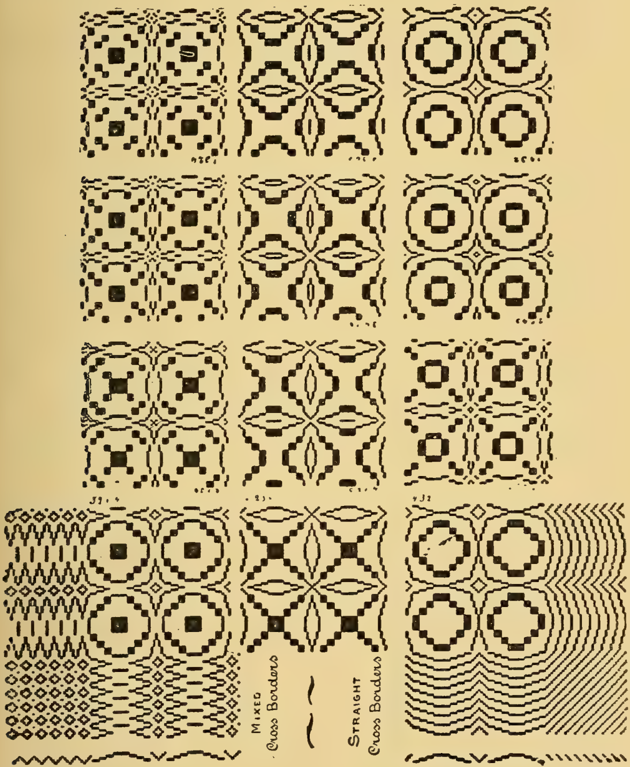


Fig. 141.—Patterns made upon the Cardless Dobby.

greatest value, and, where not directly useful, it will be capable of easy adaptation to all special requirements. Messrs. Robert Hall and Sons will be pleased to show

interested persons a loom at work with this invention applied, and also specimens of the work produced; and any other information may be obtained on application to them as above."

Fig. 140 gives a very good representation of the machine, and fig. 141 shows a few of the patterns produced upon it.

CHAPTER VII.

The Development of the Picking Motion.

The limited picking power of the loom.—Its development required for cross-stripes and checks.—Robert Kay's invention of the drop-box.—Its working described.—The hand-loom lay with drop-boxes at each end, *illustrated.*—Dr. Cartwright's power-loom multi-chambered shuttle-boxes.—Duncan's suggestion of drop-boxes.—Morison's, and Naylor and Crighton's patents.—Luke Smith's revolving boxes.—Gradual supersession of the hand-loom by the power-loom; suffering incident thereto.—The manufacture of hand-loom fancy goods the latest to be affected.—Their decay and final extinction by the improvements of the power-loom.—Final disappearance of the hand-loom cotton weaver.—Steady expansion of the shedding and picking capacity of the power-loom.—Diggles chain motion for drop-boxes.—Wright Shaw's check loom, 1868.—Shaw's further improvements, 1887.—The improved loom described and *illustrated.*—Further improvements in 1889.—Hall's revolving shuttle-box loom, *illustrated.*—Conclusion of the subject.

HAVING traced the development, and sufficiently described the shedding capacity of the loom, the growth of its picking powers may now be shown at somewhat less length. This capability, whilst very great, is not at all commensurate with the former. The shedding capacity rings, as it were, a wonderful series of changes upon the warp threads, and binds the beautiful pictures so created upon the fabric by the weft threads, as put in by the simplest arrangement of the picking power in use, the one shuttle reciprocating pick. This suffices for the most elaborate work that can be produced by the shedding capacity of the loom. It is only when another class of effects is desired, namely, transverse stripes of different materials or colour, that increased picking power is demanded from the loom. Striped textile fabrics are best

and most economically constructed with the stripe parallel to the length of the fabric, and formed by the introduction of the striping material into the warp. For all the varieties thus made the ordinary picking motion suffices. But sometimes, though rarely, a transverse or cross-over striped effect may be wanted, and then an extended picking capacity is needed. Very much oftener a new series of effects, termed checks, in which warp stripes are crossed by weft stripes, are required, and as these are of almost infinite variety, it is for their production that the inventor has been called upon to provide the means.

Checked fabrics are probably as old as the art of weaving, or very nearly so. This knowledge will have been gleaned already by the careful student from the preceding chapters, therefore the ground need not be gone over again. When, as has been seen, John Kay made his great improvement in the art of weaving by the invention of the fly-shuttle and new method of picking or throwing it through the warp, he provided receptacles at each end of the slay or lay for the reception of the shuttle, in substitution for the weaver's hands, which had up to that time received it. These were termed the shuttle-boxes, and as will be obvious, they could only take one shuttle at a time. A weaver, therefore, who was engaged in making checked fabrics, especially if the changes of material or colour were frequent, would find little advantage in Kay's invention, as the changes would have to be made by hand almost as before. The fact that it was twenty-five years or more from the time of John Kay's invention before the picking capacity of the loom was further improved, to enable it to form transverse stripes, or assist in the production of checks, shows how intellectually slow were the generations of the first half of the last century in the matter of mechanical invention; or otherwise expressed, how feeble, if existent in other individuals at all, was the faculty. The improvement was made by John Kay's son Robert, a little before or in the year 1760. There is no

record of this invention having been patented; perhaps Robert was fully aware of the practical valuelessness of a patent for protecting an inventor's interests, as illustrated in the experience of his father. The invention consisted at first in the addition of a second shuttle-box at one end of the lay for the reception of a second shuttle containing a different material or colour of weft. Necessarily these boxes needed to be movable to requirement, and were therefore imposed one upon the other, or otherwise were made of a single box with two compartments. This was placed within a frame at the right hand of the lay, and mounted upon vertical guide rods. Its range of motion was such that either compartment could be brought into a straight line with the shuttle race, thereby allowing the shuttle it contained to be brought into use when required. This arrangement was generally known as the drop-box, because the box not in use was ordinarily kept below the level of the shuttle race. To the top of the double box a cord was attached which extended upward to a horizontal lever, to which it was connected. This lever was pivoted near its centre upon a small bracket fixed upon the arm of the lay. From the second end of the lever a cord descended to another horizontal lever, arranged just over the lay cap, the free end of which came within range of the hand of the weaver operating the lay, thus, through the connections described, bringing the boxes within the control of the weaver. When work was commenced the weaver would place the shuttle containing the wefts to be used in their respective compartments or boxes, as they are called, and begin his work with the first the pattern required. This, it may be assumed, was the one in the top box. With this he would work as long as the pattern demanded; and, as there was only one box at the second end of the lay, when done with it would have to be returned to its original receptacle, in order to leave the way of the other clear from any encumbrance. A change having then to be made, the weaver, without any cessation of his work, by a finger

or thumb of the hand upon the lay cap pressed down the lever close to it, and through its connections raised the shuttle-box so as to bring the lower compartment in line with the shuttle race, and thus allow its shuttle to be brought into work. The movement by which this was accomplished at the same time carried the first box and its shuttle outside the range of action of the picker. The weaver, by keeping his finger upon the finger lever by which he had effected this change, maintained it as long as required. When this was a considerable time, say several minutes, it was usual to keep down the lever by means of a detent, or catch, which was brought to bear upon it. The demand upon the contents of this shuttle having terminated, the former condition was restored by the weaver allowing the finger lever to rise, which permitted the shuttle-boxes to drop into their first position, when the shuttle first used could again be brought into work. The operations were then continued according to the requirements of the pattern.

The above description will make it clear that a stripe of two picks wide, formed by an outward and return passage of one shuttle, might be put into any fabric, or they might consist of any even number of picks in regular order, or in such varied order as might best conduce to the attainment of an attractive design: these always limited, of course, in this simple arrangement of the duplicate shuttle-box by the carrying capacity of two shuttles, which is merely two colours or materials.

This invention opened out a vista along which its principle could be much further extended, and the boxes were therefore soon increased to three or four, and were also duplicated at the opposite end of the lay, this obviating the necessity of always returning the shuttle to the box whence it had started before another could be used, and so enabling the weaver to insert a single pick, or any odd number of picks as might be required, with the same facility as he had done two or any other even number

before. From this was derived the modern pick-and-pick-loom, a loom little known in the cotton trade, but in extensive use in the woollen and worsted industries.

In fig. 142, A, is shown a front view of a hand-loom lay fitted with three boxes, A A, at each end. These are connected by cords to the horizontal levers, B, and from the opposite ends a connection is established with the finger lever C. Both sets of boxes being connected to this lever are elevated simultaneously when the lever, C, is pressed down. The weaver operates the lay with his left hand, the right being employed to throw the shuttle. Placing his hand near

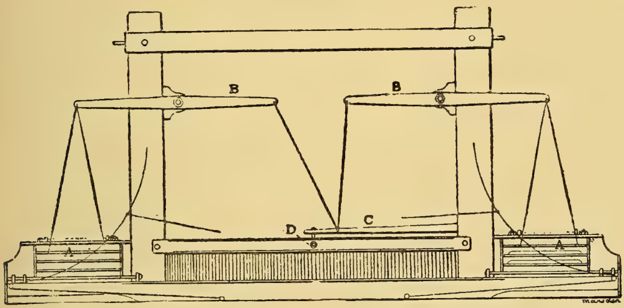


FIG. 142.—HAND-LOOM LAY WITH DROP-BOXES.

the centre of the lay cap, D, his thumb is in contact with the end of the lever, C, or may be actually upon it. When the requirement for a change of shuttle comes round he presses down the lever, brings up the desired box with its shuttle, and maintains it there until another change is made. This simply illustrates the principle of action embodied in the most highly developed box power-loom of the present day, as will be seen later on.

It is not necessary to trace in minute detail the development of the picking capacity in connection with the hand-loom after having thus shown its origin and delineated its principle. The great rival and successor of the hand-loom

was upon the doorstep as it were. Dr. Cartwright, the inventor of the power-loom, after, as he says, having invented his first loom and then condescended to go and see a hand-loom weaver at work, learnt a great deal from the inspection, one of these things no doubt being the existence of multi-chambered shuttle-boxes, with which, it will be remembered, he had not attempted to provide his first loom. But, as has been seen, no difficulty, however great, deterred him from endeavouring to overcome it. It is not surprising, therefore, to find that in his patent of 1792, the last he took out in connection with his loom, he provided these boxes. Instead, however, of arranging them in vertical order, he placed them side by side, providing mechanism to give them a horizontal movement backward or forward according to requirement. This, however, does not appear to have been successful, as little or nothing was afterwards heard of it. In fact, the doctor's loom in its best form was too crude and imperfect to justify any attempt to render it still more difficult to manage by adding to its complexity mechanism to perform more than the simple process of weaving plain fabrics. The science of mechanics was too young, and the art of machine construction far too crude and rough at that date to permit of the successful embodiment in a machine of all the doctor's brilliant conceptions.

Thirty years of slow progress had to pass away before multiple shuttle-boxes became a practicable reality in the power-loom. Still it appears they were successfully introduced on the type of Robert Kay's plan, termed the drop-box, but when or by whom we have not discovered. Mr. Barlow in his "History of Weaving," referring to this matter, says: "It seems, however, not to have been carried out successfully until many years afterwards, for, in 1830, Mr. Duncan states, in an article in the 'Edinburgh Encyclopædia,' that it appeared extraordinary that no plan for that purpose had yet been adopted, and he therefore suggested one. His contrivance consisted of five shuttle-

boxes placed upon the outside segment of a cylinder, and an arm connected thereto being brought into contact with a series of studs or projections placed upon a ratchet wheel, which, being turned by the loom, caused any required box to be placed under or in line with the picker." This introduces the principle of a revolving arrangement of the boxes. It seems, however, almost incredible that the simpler form of the drop-box system had not come into use before then, as in 1836 James Morison took out a patent for actuating a system of boxes in conjunction with the working of a jacquard on an improved plan. In this the boxes seem so numerous, and the working arrangement so complex, that it is fair to assume that they must, on a smaller scale and simpler plan, have been at work for a long time. Three years later, Naylor and Crighton, two inventors, jointly patented an improvement for actuating the drop-boxes of a loom.

On November 16th, 1843, a patent was granted to Luke Smith, for "the construction of a revolving shuttle-box, containing a number of compartments arranged round the axis of the box, each of which is formed to hold a shuttle." This realizes the principle just named. On the axis of the shuttle-box two plates were fixed, each having three projections, or catches, which corresponded in number to the compartments in the shuttle-box. These catches were actuated by two levers on a stud fixed in a bar attached to the breast-beam; one lever turned the shuttle-box in one, and the other lever in the opposite direction. The levers were brought into operation by studs on a belt attached to a drum which was turned by a ratchet-wheel and lever, actuated by the lay.

These details show that between 1830, if not before, and 1845, both drop and revolving boxes had been successfully adapted to the power-loom. We say adapted, because the first if not both had long enough been in use upon the hand-loom.

For the first twenty years of the present century the

power-loom, owing to its numerous defects, had only made little progress. In 1813, there were only 2,400 in all Great Britain, and a rather large proportion of these were Robert Miller's "Wiper" loom, as it was called. In 1817, there were only 2,000 in Lancashire, half of which were unemployed. But the slow process of improvement was now beginning to make it a formidable competitor of the hand-loom. From the opening of the century to 1820 the number of hand-looms had probably ranged between 250,000 to 300,000, employing probably 400,000 to 460,000 persons. The greatest proportion of these looms were, of course, engaged upon the manufacture of plain fabrics, and it was these that first fell beneath the competition of the new loom. In the year 1823, Mr. Guest, one of the early historians of the cotton trade, estimated that there were 10,000 power-looms in England alone. These supplanted a much larger number of hand-loom weavers. The process was one purely of supplanting, as under the commercial *régime* then existing there was not much room for the extension of trade in old, or the opening up of new markets, as tariff laws made it impracticable to accept for cotton goods such productions as foreign populations could offer in exchange. For several years, the displacement of the hand-loom by the power-loom went on at an accelerated rate, as in 1825 the number of the latter had risen to 30,000, reducing wages and throwing large numbers out of employment. The bad harvests and commercial panic of 1825-6 suddenly and heavily accentuated this trouble, and led to the rise of the weavers in semi-rebellion, the result being the loom-breaking riots by which that period was distinguished. Thus the second chapter in the history of the new industry became a singular reflection, both in causes and consequences, of the first. In the last-named, as we have seen, the invention of the spinning-jenny, the water frame, and the mule displaced the services of the hand-wheel spinners, and led to rioting and serious disorder. This, however, was not so severe and prolonged as that

which sprang from the power-loom's displacement of the hand-loom and the weavers who wrought upon it. The number of the latter was far larger, and the processes of extinction and absorption were much slower. Better harvests, and an improvement in trade during the year or two after the riots we have named, softened the transition from the manual to the mechanical system, the younger people and the children taking to the new occupation, and so by their earnings compensating to some extent for the loss of those of their parents. By 1833 the number of power-looms had risen, in England to 85,000, and in Scotland to 15,000. At this time a power-loom weaver, assisted by a child of twelve or thirteen years of age, could attend to four looms, and weave eighteen pieces of 9-8 shirtings per week as against two pieces of the same by a hand-loom weaver. This was the death-warrant of the plain cloth hand-loom weaver. This great change was brought about immediately by the invention of the Blackburn loom by the late William Dickinson, which was first made at the Eagle Foundry, Blackburn, in 1828. Before 1840 this, which had been the largest branch of the hand-loom weaver's occupation, was extinct, and the younger portion of those who had followed it had been absorbed in the new system, the middle generation utilized as labourers in the mills, whilst the oldest had become dependants upon the younger members of their families or had sought refuge beneath the wings of public charity.

There was one considerable section of the industry however which, up to this date, had not been much affected, namely the manufacture of stripes, checks, spots, and figured fabrics, comprehensively termed the fancy trade. The weavers in this branch flattered themselves that these goods could never be made upon the power-loom, and that their occupation could not be successfully assailed. In this they were of course mistaken. No sooner was the loom made approximately perfect for the production of plain goods than inventors set to work to develop its

capacity in the production of fancy articles. These attempts began about 1820, and though little progress was made during the first ten or fifteen years, it was quite sufficient to justify a continuance of effort. One problem after another got solved, and every year that passed saw new territory conquered from the hand-loom and annexed by the power-loom. By 1850 it became obvious that the extinction of even this branch of the old industry had been brought within a measurable time. The adoption of a free trade policy by the country accelerated its arrival, and the American Civil War gave it its *coup de grâce.* At that time the sole surviving demand for hand-loom muslins came from the Western States of the Union and from Canada. That from both sources was destroyed by the war. The small number of hand-loom manufacturers who had remained in the trade closed up their businesses and transferred their capital to other industries, or retired from active commercial life. A few entered the new cotton trade as employers, and as long as they lived kept their old weavers around them as semi-charitable dependants. Time, however, speedily diminished their numbers. The Ribblesdale valley from Preston to Clitheroe was the locality in which they lingered longest. During the years 1885-90 perhaps three or four might have been found in the neighbourhood of Longridge and Ribchester. One of these whose craft had abandoned him was brought from his retirement in the almshouses at Knowl Green, near Stoneyhurst, to the Manchester Jubilee Exhibition in 1887, where, in the " Old Manchester " section, he plied his craft to show modern weavers how their forefathers used to work. From a conversation with him, the writer gleaned that he was an octogenarian, and, as far as he knew, he was almost the last survivor of his industrious race. It is doubtful now (1894) whether a single one survives. Thus passed away a type of industry, picturesque far beyond its successor, that from 1750 to 1850 found employment for several millions of people. Though it has

only just disappeared, it has hardly left as many footprints behind it as have the Roman legions that sixteen or seventeen hundred years ago tramped over the country in which it was carried on.

The causes of this disappearance of the old form of the weaving industry were the invention and steady expansion of the capability of the power-loom, as seen in the improvement of its shedding and picking powers. In reviewing the development of the latter it is only intended to make a brief allusion to the various inventions that have proved steps to the highest and most recent achievements that inventors have made. The latter seem to leave little to be accomplished or even desired, and of these a fuller description may be given.

It has already been stated that James Morison took out a patent for actuating the shuttle-boxes by connection with the jacquard. This was an important invention in its suggestiveness, as it indicated the principle by which any kind of action of the shuttle-boxes could be obtained according to desire. Whether immediately subsequent inventors utilized the plan or not does not matter much now, but it is certain that it has proved the most successful of all principles in the actuation of boxes.

The invention by Luke Smith of the revolving system of boxes has also been already referred to. He appears to have been the pioneer in the construction and application of this plan to power-looms.

On January 11th, 1845, a patent, No. 10,462 was granted to Squire Diggle for an invention which has proved to have been of the highest merit, having held its ground almost to the present day, and which has been known ever since as Diggle's chain motion. The chain, which is the feature of the invention, is constructed of a number of plates or cams of different shapes and sizes. The length of the chain depends upon that of the pattern. Each cam or link constitutes a tappet for a certain box, and any box can be kept in action by repeating the cam which first brought it into

position. Also any box, whatever be its position, can be brought into action by a cam of the requisite size to raise or depress it to the position needed from the one it occupies at the moment. The invention incorporates the principle of the jacquard.

The next advance of considerable importance in this direction consisted of the improvements made in the drop-box check-loom by Wright Shaw, and covered by patent No. 2219, July 14th, 1868.

The first of these consisted in the introduction of double-acting levers, reciprocating in opposite directions and acting in combination with a bowl mounted on one of the levers, which was caused to slide in a lateral direction by a lever motion, governed by the pattern chain, so as to bring the bowl in contact with one of two tappets of different diameters, thereby giving movement to the double-acting levers and bars suspended from them, and which were provided at their lower extremities with notches or teeth. When in contact with either of the tappets, the bowl was held or locked in position by means of a finger attached to the lever motion, which caused the bolt to slide. The second was an improved construction of the box-rod, the lower part of which was provided with a series of notches corresponding with those on the suspended bars. The pattern chain through these bars gave the required motion to the drop-boxes. The third was an improved method of actuating the chain; and the fourth an apparatus for varying or retaining at requirement the number of picks from any one card. The same patent also covered a number of other improvements of a minor character. The whole, in their effect, constituted a large advance upon what had gone before, and "the Wright Shaw loom," as it became known, soon took a leading position in the estimation of the trade. It was extensively adopted, and still continues largely in use. Students who desire to learn more of its details will find them given at length in the patent

specification, the number and date of which are given above.

A few years ago the same inventor made further improvements upon this loom, and which appear to have left little space for future progress. As now constructed our illustration (fig. 143) gives a good idea of its general

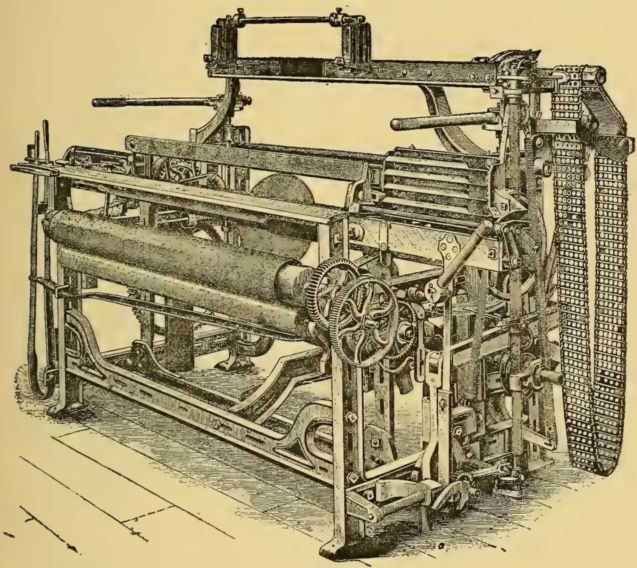


FIG. 143.—SHAW'S DROP-BOX POWER-LOOM.

appearance, whilst the group of illustrations in fig. 144 exhibit the various parts and explain their functions.

The object the inventor had in view was to simplify the construction of the drop-box motion, and to bring its principal parts within cognizance of the eye and easy reach of the hand of the weaver, by which liability to derangement would be diminished; to facilitate access to the working parts; to increase production; and to econo-

mize space. The details by which these ends are accomplished are shown in the group of illustrations under the general number 144. They are, however, numbered with subordinate numbers, from 1 to 6, and these are used in

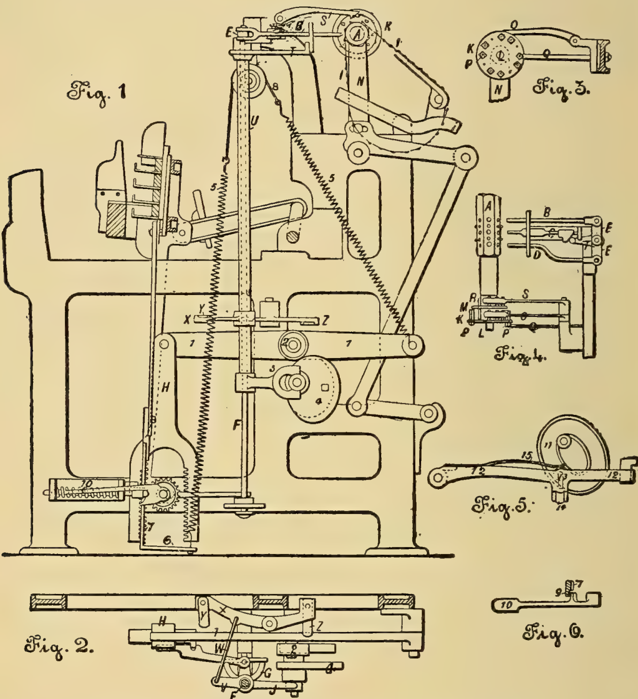


FIG. 144.—SHAW'S DROP-BOX LOOM (DETAILS).

the description. These ends he accomplished by removing the pattern cylinder, A (figs. 1, 4), and the horizontal rods, B, C, D, in same figs., from the bottom of the loom, where they are usually placed, to the top of the loom frame to which in the alteration they are bracketed.

The construction was simplified by dispensing with two of the pegged cylinders usually employed. The swivel bracket, E (figs. 1, 4), formerly attached to the outside of the sliding rods, is now fixed upon the top of an upright shaft, F, to the bottom of which is attached a second swivel bracket, G (fig. 2), which moves the "boot-jack" into or out of gear. The pattern chain, I (fig. 1), is economized by mounting a disc, K (figs. 1, 3, 4), upon the peg cylinder, L. On one face of this disc are a number of pegs, M, which, by the oscillation of the cylinder bracket, N, are brought within reach of the hook, O, which causes the disc to make a portion of a revolution. On the opposite side of the disc, K, are a number of screw-pins, P (figs. 3, 4), which in the revolution of the disc are brought into contact with a stop, Q (figs. 3, 4), fixed to the frame. When this occurs a second disc, or spider-wheel, R (fig. 4), of similar construction, fails to get within reach of its hooked catch, S, and thus the pattern cylinder, A, is arrested in its revolution, which permits the pattern on the card facing the horizontal sliding rods, B, C, D, to be repeated a definite number of times, until the omission of one of the screw-pins, P, allows the bracket to beat up its full distance, and the catch, S, to fall into gear with the spider-wheel, R, and by giving an eighth of a revolution to the cylinder, A, to bring up a fresh card and to make the required change. By this arrangement a pattern card can be made to repeat itself four, six, eight, or twelve to twenty-four times. This effects a great economy in the length of the chain.

The arrest of the normal movement of the cylinder bracket is also effected when one of the screw-pins, P, comes against the stop of the cam, 11, shown in fig. 5. This cam actuates the lever, 12, which in its turn operates the cylinder bracket. It is made with a groove, and the bowl, 13, on the lever, 12, is mounted in a sliding fixing, 14, on which the plate-spring, 15, presses, allowing the lever to give way, although the bowl, 13, still keeps travelling in the groove. By this means the ball weight

usually employed is dispensed with. The same effect follows when the lever, 12, is held down by the ordinary action of the weft-fork motion when the weft thread breaks or runs out.

The lever, T, attached to the central sliding rod, C (figs. 1, 4), is mounted on a tube, U, through the centre of which passes the upright shaft, F (fig. 1, marked with dotted lines in its upper portion), and on this tube is fixed the short arm, V (fig. 2), connected by the link, W, to the lever, X, which carries two short plate-springs, Y, Z. When the two outer sliding rods, B and D (fig. 4), are working for a single lift of the shuttle-boxes, only the spring, Z, just above the bowl, 2, acts upon the boot-jack lever, 1, and prevents any jumping of the boxes when working at high speeds. But when the central sliding rod, C, comes into action, the arm, V, on the tube, U (fig. 2), acting on the spring-lever, X, removes the spring, Z, from the boot-jack lever, and causes the spring, Y, to act on the same a point further from the fulcrum, by which it exerts an increased pressure when a double lift of the shuttle-boxes is being made. At the lower end of the tube, U, is fixed the fork, 3, for throwing the double-lift cam into or out of gear.

For a long time great drawbacks to the use of rising or falling boxes for checking purposes were experienced in the wear and tear caused by the fall of the boxes from one position to another, and the large amount of power required to raise them, especially when "skipping," that is, passing over more than one box in a single movement, took place, and which arose from there being no counterpoise. These have been overcome by Mr. Wright Shaw in a simple manner. Two long helical springs, 5 and 5′, have been introduced; one is attached to the loom frame at the back, and the other to a horizontal bracket, 6, fixed to the foot of the vertical rack which carries the shuttle-boxes. The two springs are connected by a strap, 8, passing over a small carrier-pulley. In an instance like

this long springs are an advantage, as they enable the strain incident to working to be distributed over a considerable length. On the side of the shuttle-box rack a projecting flange, 9 (fig. 6), is fixed, against which the action of a stud or projection throws back the rack, removing it from its gear with the pinion when it is desired to readjust the boxes. The same thing occurs when any derangement of the working parts takes place. The flexibility thus secured very effectually prevents the breakages that often occur where no such provision is made.

In fig. 1 it will be seen there are two spring hand-levers. The ordinary one is for transferring the driving-strap to or from the driving-pulley, whilst the second is to control the pattern-card motion. In operation the weft-fork motion controls not only the strap lever, but also the lever in front of the illustration, which through its connections governs the action of the pattern-chain. This arrangement gives the weaver great facility in securing correctness in the patterns, which is a very important matter in the manufacture of checked goods.

This loom as we have described it, was shown in the Jubilee Exhibition at Manchester, and very deservedly excited a great deal of interest. Its author, however, under the restlessness which distinguishes a full measure of the inventive faculty, could not leave it alone, and within the next three years introduced several further improvements, having for their object increased simplification, to be attained by removal of every part of the mechanism which the closest study might discover could be spared. The result was that two or three further modifications of a very useful character were made.

The first was the introduction of a new pattern arrangement. The front spring lever handle seen in the illustration, as previously described, is the pattern rod lever, which has an attachment extending across the frame of the loom in front of the swing rail. On the end of this

rod is a projection which is made thick towards the end in order to bring it nearer to its work. When the loom is at work this is held out of action by the pattern rod handle standing in its detent. When the weft breaks, or is exhausted, the weft-fork lever pushes both the spring handles out of their detents, and the change of position of the pattern handle instantly carries the projection at the end of its rod to a position which immediately stops the revolution of the pattern chain. Though the loom may run a pick or two further, the pattern chain remains in the right position for immediate resumption of work at the point where the weft broke, thus dispensing with the general requirement for readjustment and the loss of time usually involved, and also the risk of damage or depreciation of the cloth when this is not accurately done. The manufacturer of these classes of goods will fully appreciate the value of this improvement. Better work and a greater production are the outcome.

Another useful change was made by the introduction of a single-lift cam placed upon the end of the picking shaft. This cam has an eccentric cast upon the end of its boss, which does away with one setting point, the eccentric having previously had to be set separately and in perfect harmony of movement with the cam, which was a task not easy of accomplishment. The combination of these two parts left the interior of the loom perfectly free from every encumbrance, and available for tappets, twill motions, jacquard harness or any shedding appliance that it may be desired to introduce. The picking mechanism is entirely placed outside, thus becoming much more convenient of access.

The eccentric just named has a groove cut into its periphery into which a connecting rod descends, its end thus acting as a retainer of the clip in its position. The upper extremity of the connecting is attached to a sliding and rocking bracket, which is grooved in its upper part. By this groove it is attached to a bell-crank lever on

the extremity of which are cast two studs, upon which the bracket is placed. The bell-crank lever carries a fixed bolt, to which is attached, through a connecting rod, the pattern rod and the mechanism it governs.

We may now very briefly deal with the revolving shuttle-box. Though extensively used in the worsted districts, the revolving box-loom is not an important one in the cotton trade. It is so called because, as has already been explained, the shuttle-boxes are arranged round the circumference of a circle, and revolve on a shaft or axle forming the centre or axis. The two illustrations, figs. 145 and 146, the first showing the general appearance of the loom carrying revolving boxes, and the second their mounting and details, clearly explain the mechanism. The parts referred to are lettered alike as far as this can be done. The shuttle-boxes are mounted around the shaft or axle, A, which is arranged in a suitable frame in such a manner as to permit it to revolve freely. Round the boxes at the end nearest the reed a metal ring B is introduced, on the outside of which is fixed a second metal ring, with an arrangement to form a brake upon the ring B, in order to prevent the boxes going too far when put in motion. The boxes are actuated by two hooks, C C^1, placed at the end opposite the one just mentioned. These hooks are placed one on each side of a pegged disc, D, and have an intermittent ascending and descending movement. The position of the boxes is changed in the descending motion, the ascending one being simply to place the hooks in position ready for operating when required. The hooks, C C^1, being placed on opposite sides of the pegged disc D, can work the boxes to the right or left; that is, can cause them to revolve backward or forward accordingly as they are operated by one hook or the other. The hooks are brought into action by the steel plates, commonly called steel cards, E, which are changed according to the colours required to be put into the fabric, the change bringing the box containing the shuttle with the colour of weft re-

quired into action. These steel cards are carried on a revolving barrel, F; some are blank whilst others have holes punched into them. Two inverted levers, L, with pendant needles, H H[1], at one end are presented to the steel cards. If the card present on the cylinder be blank, no change can occur in the position of the boxes; should it be perforated, the needle enters, and the end of the lever, L,

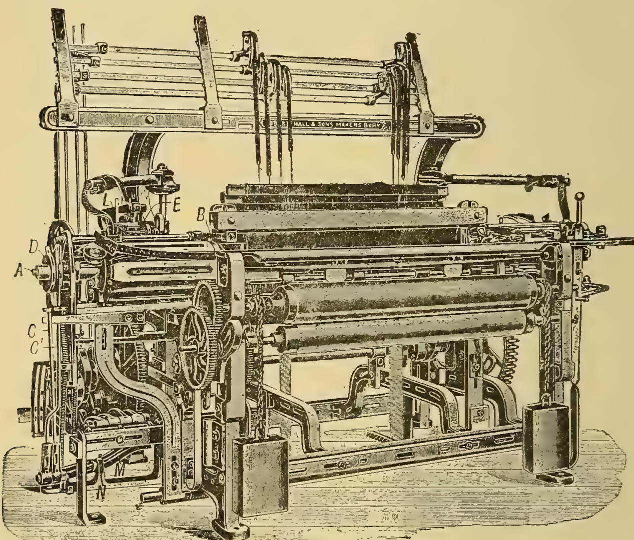


FIG. 145.—REVOLVING SHUTTLE BOX-LOOM.

carrying it descends to a lower point than it would have done had the card been blank. The opposite end of the lever then operates one of the two hooks, I, which are fixed in the path of the lever K, this having a continuous alternating up-and-down movement. The lever K on its ascending movement raises the hook I, and this hook being connected to the hooks, C C[1], by means of a lever, M, having its fulcrum at N, depresses one of the hooks, C C[1], changing

the position of the boxes as desired. The lever K is actuated by an eccentric, P, placed generally upon the tappet or second motion shaft of the loom. The needle end of the levers, L, have a suitable motion to elevate and depress them, and each time they are raised the card

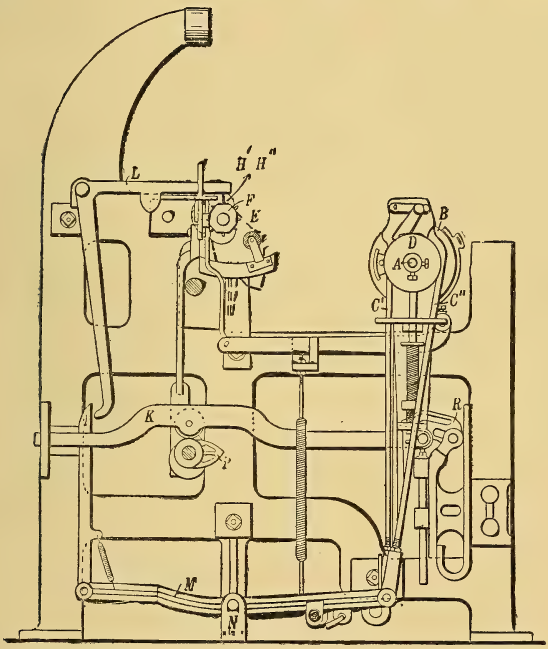


FIG. 146.—REVOLVING SHUTTLE BOX-LOOM. (SECTION.)

barrel, F, is changed in its position, and made to present a different card to the needles. At R an arrangement is made which will permit the lever K to slip in the event of a shuttle not getting into the box, thereby avoiding breakages.

This is one of several systems adopted for actuating

revolving shuttle-boxes. They differ only in details of construction, each, like this, embodying the principle of Jacquard's invention.

At this point we may appropriately close our notice of the development of the picking or shuttling capacity of the loom. There are, of course, many inventions that might seem, with equal justice, to demand as much notice as has been accorded to some of those described; but as a rule they either embody the principles of those noticed or find little place for their use in connection with the cotton trade. To describe every good invention would also carry this work far beyond the compass originally designed, which even now threatens to be considerably exceeded.

Having thus thoroughly dealt with the loom, the various preparatory processes now call for description. In connection with these the machinery employed in them will come under review, but the machines being for the most part simple and modern, the task of reviewing them will neither be a heavy nor a prolonged one.

CHAPTER VIII.

THE WINDING AND WARPING PROCESSES AND MACHINERY.

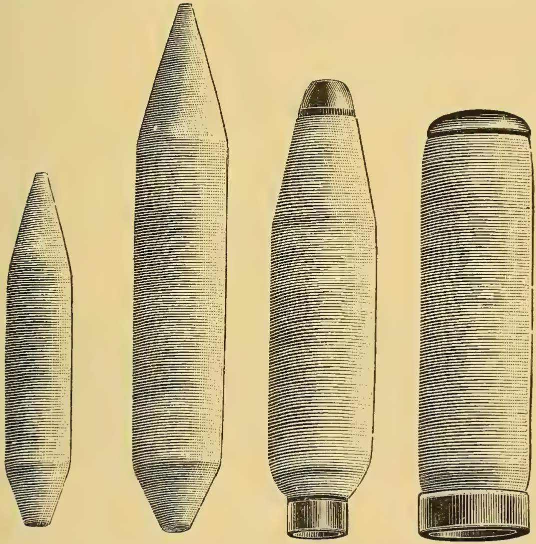
The accumulation of yarns in cop and bobbin forms, *illustrated.* —Indian winding, reeling, and warping, *illustrated.*—Old English peg warping, *illustrated.*—The old textile technical words, "beer" and "porter."—Invention of the old circular or ball-warping mill; description; *illustrated.*—The multiple spindle winding machine; inventor not known; description; *illustrated.* — Mangle-wheel motion, *illustrated.*—Improved bobbin winding machine for ring-frame bobbins, *illustrated.*—The coloured goods trade.—Improved hank reel, reeling from cops, *illustrated.*—The Coleby reels, *illustrated.*—The yarn bundling press, *illustrated.*—Reeled yarns for bleaching and dyeing, and their treatment.—Hank winding, and hank winding machines, *illustrated.*—The invention of dressing and sizing machines materially change the method of warping, namely, to beaming.—The invention of the beaming machine.—Its improvement by William Kenworthy.—Rosseter's and Singleton's automatic-stopping beaming machines, described and *illustrated.*— The measurement of yarn upon beaming-machine beams.—Coloured goods trade; section-warping machine, described and *illustrated.*— Method of working it.—The section-beaming or "running-off" machine, *illustrated.*—A new warping mill for making ball warps for bleaching or dyeing purposes, *illustrated.*—A new dressing and beaming machine for coloured warps, *illustrated.*— The warp chaining machine, *illustrated.*

IN the cotton manufacture, as it exists to-day, the winding and warping processes are sometimes found connected with the first or spinning division, but most generally with the second or manufacturing division, the one forming the subject of this essay. Occasionally, though less rarely now than thirty or forty years ago, they are found combined as an intermediate and independent branch, that is, are conducted as a business separate from either of the principal divisions. They have, however, as such almost disappeared, having been absorbed by the principal sections.

These two processes are rendered necessary by the

forms given to the yarn as it accumulates in the spinning processes. It has been shown in preceding pages that the distaff spinner accumulated it upon the spindle, winding it length by length as it was spun, and forming copes at each end of the mass, in order to prevent entanglement. The hand-wheel spinner followed the same plan, both in making rove and yarn. The necessities of the situation compelled Hargreaves in his jenny to do the same, and the like inexorable power forced Samuel Crompton into the same groove. Subsequent inventors, who have added improvement after improvement to the mule, have retained the same method of accumulating the yarn and the same form of the accumulation. The form of the figure is a cylinder, with two conical ends of unequal length. The shortest cone forms the base or bottom, and the longer the top or nose. This is yarn in the "cop" form, which is a word derived from and a contraction of the word cope, indicative of the coped extremities of these cylinders of yarn. This word, or its equivalents in various languages, is of very ancient origin and use. These cops, until the time and invention of Richard Roberts' self-acting mule, were always formed by the manual skill of the spinner. After that time they were made automatically on his "self-acting mule." A full description of this, along with the construction of the cop, will be found in the present writer's work on "Cotton Spinning." Both warps and weft yarns were accumulated in this style. For the sake of students who may not be in contact with either branch of the trade, several illustrations (fig. 147) are given of cops and bobbins from the self-acting mule, and the ring spinning frame. The first two, A B, are cops from the self-acting mule, A being a cop of weft yarn, and B of warp yarn or "twist" as it is most commonly but erroneously called. The third, C, shows the ordinary ring frame bobbin filled with yarn; and D a ring frame bobbin with what is termed the parallel build. These are all shown about one-third their actual size.

The first departure from the cop form of accumulating the yarn was made by the inventor of the Saxony or flax spinning-wheel, on the spindle of which a "flyer" was carried. In winding the yarn with this method of spinning it could not be coped, hence double-headed or flanged bobbins became necessary, and were accordingly provided.



A. B. C. D.

FIG. 147.—MULE AND RING FRAME YARNS ON COPS, SPOOL, AND BOBBIN.

Arkwright adopted this spindle and flyer in his water-frame, and of necessity the flanged bobbin. It was continued in the improved water or throstle frame, but has in most cases been discarded in its successor, the ring spinning frame. In a recent and valuable invention, the improved ring spindle of Mr. Thomas Wrigley of Todmorden, the cylindrical build and the double flanged bobbin have been

reintroduced. The above illustration, D, is from Mr. Wrigley's bobbin.

As each of these cops and bobbins contains only one strand of yarn, it will be obvious that to put from one to three thousand of them behind a loom in order to make a warp, would be inconvenient if not impossible, therefore some intermediate process or processes are necessary.

FIG. 148.—INDIAN WINDER.

These we find in what are termed winding and reeling, and warping.

In India, the primitive home of the cotton industry, the operative wound the yarn from the spindle cop upon a bamboo frame, as shown in the illustration, fig. 148. This was practically a single thread reel, and the yarn was no doubt thus reeled into the hank form, in order to admit more readily of being sized or starched in order to increase its strength, and enable it the better to resist the friction incident to weaving. It would also be necessary for the dyeing process. The sizing was performed by

immersion and saturation in rice water. A further advantage would also probably accrue, in that the contents of several small cops would be reeled into one length, and thus fit it better for a warp length.

When the sizing had been properly performed and the yarn dried, it was again put upon the hand reel and straightway formed into a warp. The manner in which this was done is shown in the illustration, fig. 149, where it will be seen the warper having put a number of sticks into the ground, fastens the yarn to the end one, and then

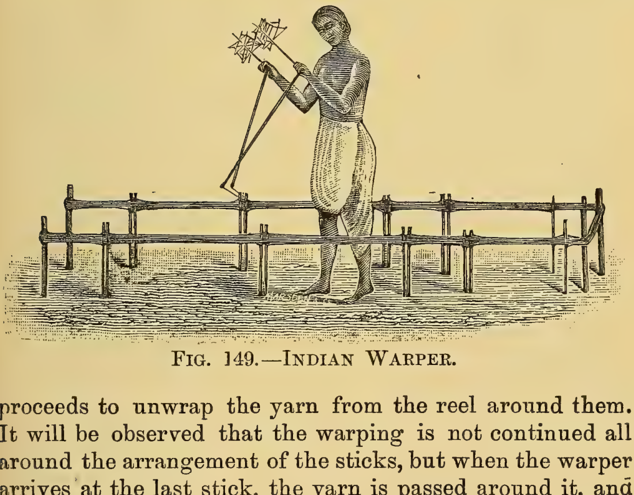


FIG. 149.—INDIAN WARPER.

proceeds to unwrap the yarn from the reel around them. It will be observed that the warping is not continued all around the arrangement of the sticks, but when the warper arrives at the last stick, the yarn is passed around it, and the first course is gone over again in a backward direction. Thus a journey from the first stick to the last and back again adds two threads to the warp, or according to the arrangement, two lengths of one thread. This is continued until a sufficient number are obtained, when the warp is completed. It will be quite obvious that this is a very monotonous and laborious process, as it compels the worker to pass over a distance equal to the united lengths of every

thread the warp contains, it not appearing that the warper carries more than two threads. This system is not only the ancient one, but has come down to the present day, and is the method in most cases now followed where the domestic industry still survives. But both spinning and weaving in India in the ancient forms have greatly diminished, and must ultimately disappear before the modern systems, just as they have already become extinct in this country.

Before the invention of the water frame by Arkwright, the so-called cotton goods were really unions, having linen warps filled with cotton weft. The yarn of these warps was delivered to the weaver in hanks. This was the weaver's raw material, just as cop or bundle yarns commonly are to-day. The weft, when it was not dyed, was usually received in the cop form. When it was found that cotton yarn from the water frame could be used for warps, this was also delivered to the weaver in the hank state, as being most convenient to the spinner and most in accord with the habits of the weaver.

Cotton yarn was subjected to the same processes that linen passed through. Both were boiled in the hank, in water to which soap or potash had been added. Afterwards flour was added to the water in which cotton yarns were boiled in order to increase its firmness and tenacity. When the yarn had been thoroughly dried it was wound upon bobbins upon the common one-spindle hand-wheel, which may occasionally be seen in use to-day in our smaller weaving mills for the purpose of winding heading yarns. The hank was extended upon and between two small wheels called whisks, fixed upon an upright post and revolving upon their centres.

The bobbins thus prepared were delivered to the warper for him to form into a warp of a given length and breadth. Warping is merely the laying of a number of threads in parallel order, and equal in length, and in number sufficient to make the required width of cloth. In the

early days of the industry this process was almost identical with that of the Hindoo as previously described. This will be seen from the accompanying illustration, fig. 150, which is from an old print. Here it will be seen the pegs instead of being stuck in the ground are fixed in a wall, and the warper takes the yarn, attaches it to the outer peg, passes it under and over the others in alternation to form a lease, and then carries it to the most distant one, around

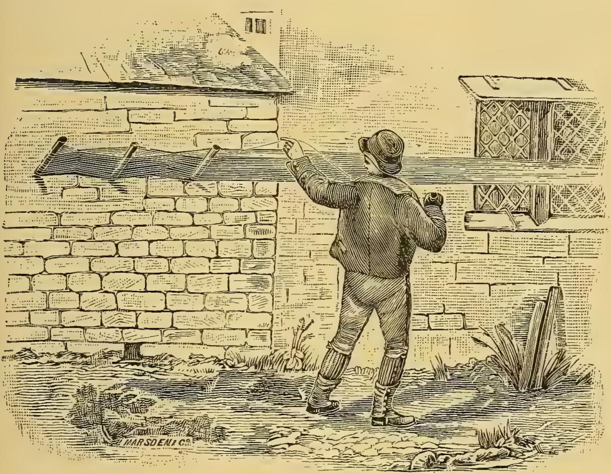


FIG. 150.—PEG WARPING, AN ANCIENT ENGLISH METHOD.

which having passed it, he returns to his first position and repeats the operation. Undoubtedly in the earliest times the English warper would thus carry every thread as does the Hindoo, but some time or other, it is undiscoverable when, he would find that his walking would be greatly diminished if he carried more than one thread at a time. The new idea was accordingly put into practice with great advantage. The warper having got a number of clues or balls of yarn together, placed them in a box or some kind

of vessel, gathered the ends of the threads together, and having attached them to the peg in the wall as stated above, he took them all in his hand, and permitting them to slide between his fingers, walked to the other end of the warp course, passed them around the peg placed there, and then returned to the first. This double journey formed the length of the warp, and was called a *bout* or a warp *gang*, meaning once about the length, or a going of the distance equal to the length the warp had to be made. Assuming that the warper carried 20 threads with him, 100 journeys, or "gangings," to use the Scotch term, would give him a warp of 2,000 threads. If he carried 40 threads, 50 "bouts" would do the same.

In these days many students of the textile industries in reading and otherwise investigating the origin and progress of the textile arts will come across names that are apparently quite inexplicable, and will fail to gather any idea of their proper meaning in the relationship in which they are employed. Amongst these not the least puzzling are the English word "beer" and the Scotch word "porter," as used in the textile industries. He may hastily conclude that they are somehow derived from the two drinks of those names; to do so, however, would be very erroneous. They are synonymous terms, meaning exactly the same thing on opposite sides of the Tweed. It is in these journeys of the old warpers that we shall discover their origin. In both cases they represent the standard maximum number of threads the warper would carry in one going, or one bout, and this would probably be forty threads. His bearing or portering of these threads would soon come to be called a "bear," subsequently corrupted into a "beer" in England, and a "porter" in Scotland, from the thing ported or carried. The quantity of threads included in these terms afterwards became a unit of measure, and thus having lost their original significance, came to indicate something entirely different, this being a unit of reed measure equal to twenty dents,

as they would be expressed in England, or splits according to Scottish nomenclature. Thus 100 dents or splits in all kinds of reed measures are, or rather were, for the terms have largely gone out of use, divided into five equal portions of twenty each, and these names given to them. As each dent or split usually carried two threads, we get forty threads to the "beer" or "porter." In making the warp, if the warper was not both skilful and careful, there was a great liability for these beers to get slightly twisted, in which state they became very troublesome to the weaver when they reached him. In putting the warp upon the weaver's beam, or beaming, as this was called, these "beers" were usually divided into two portions by the teeth of the "wraithe" or "raddel," a coarse comb used to guide the warp upon the beam in an even manner. This explanation, by disabusing and clearing the minds of students of the liability to attach wrong significances to these terms, will enable them to read with more understanding the older literature of the textile industries.

The winding on the common hand-wheel, and the peg-warping described and illustrated, were universal in this country until 1760, when the warping mill was invented and first introduced. Like all other things in those times its adoption was slow, and the old system, especially in the Lancashire woollen trade, did not disappear until more than the first third of the present century had passed away. In the cotton trade, however, it was adopted earlier, as the money made in the new invention was a stimulus to enterprises at the same time that it provided the means of carrying them out. The old warping mill and the warper are shown in fig. 151. As will be seen the mill, as it was called, consisted of the vertical creel containing the four rows of yarn bobbins, and the large vertical reel, B, mounted within the frame extending over it. On the bottom of the vertical shaft or axis of the reel there was fixed a grooved pulley, I, connected with the driving pulley, C, by means of the rope, D. In working

it the warper took his seat as shown at A, turned the handle behind him fitted on the shaft of the pulley, C. As this revolved it transmitted motion to the reel, B, which began to revolve. The driving pulley being about double the diameter of the pulley on the shaft of the reel, the latter made two revolutions for one of the former. In an earlier form the driving band passed around the reel itself.

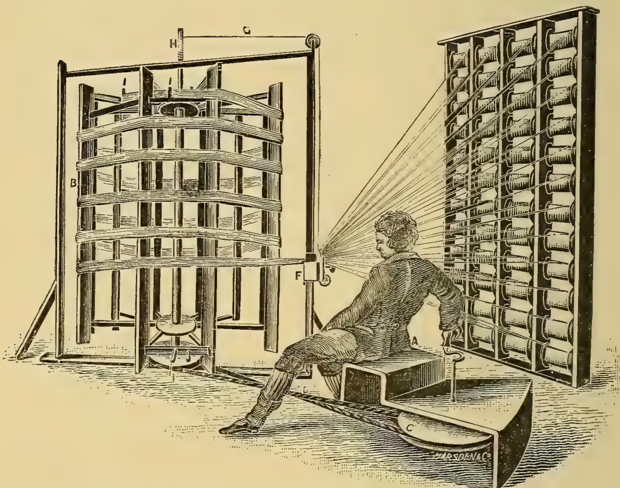


FIG. 151.—THE WARPING MILL ABOUT 1810.

This shows the great advance made by this invention in the amount of work that could be produced from this machine as compared with peg warping, and the extent to which it diminished the labour of the workman. As shown here the creel contained only forty-eight bobbins, a small increase upon the "beer." It ought to have been previously observed that before commencing work the warper gathered together the threads from the bobbins, and passed them in certain proportions between the teeth of a coarse comb carried in the frame, F, and attached them

tied together to a peg upon the reel, and then under and over the lease pegs similar in manner to what is shown in fig. 150. The yarn was then traversed upon the reel automatically by means of an extension of its axle at the top, where it is seen to rise above the frame at H. To this extension a cord was attached which extended horizontally to the small pulley shown over which it passed, and was attached to the frame, F, carrying the comb. When commencing work the cord was wound upon the axis, and gradually uncoiled as the reel revolved until it had all run off, and the frame, F, was at the bottom. The yarn was then passed around a retaining peg, and the revolution of the reel reversed, the cord winding upon the axis, and the comb frame ascending. These courses were repeated as often as necessary to get the number of threads sufficient to make the width of cloth required. When this was accomplished the warp was ready for "doffing." The warper disconnected the threads coming from the creel, took one end of the newly formed warp in one hand, and drawing the warp from the creel with the other, cleverly wrapped it around the arm, holding the end, and so ingeniously and skilfully formed it into a ball, tying it in the middle with the last portion of its length. The making of this ball of the product gave the name of ball-warping to the method. Subsequently both reel and creel were greatly enlarged, the former in diameter and the latter in the number of bobbins it would contain. It was also adapted to be driven by water or steam power. It still holds its ground in some of the more remote country districts where a conservative sentiment prevails, and old warps are believed to be the best.

The multiple spindle winding machine appears to have been a somewhat later invention than the warping mill. It is very likely a suggestion derived from Hargreaves' spinning jenny; hardly any thoughtful person could see that machine without it suggesting its suitability for winding purposes, with very slight modification in the

way of simplifying it. There is no record of its invention, and no doubt like Topsy in "Uncle Tom's Cabin," it "growed," and no one could have claimed to be its parent with certainty. Notwithstanding this, it formed a considerable advance. The first recorded patent we have found is that of William Pride, No. 4,666, granted April 16th, 1822. This improvement consisted in putting on the driving shaft of "the spooling frame," "two wheels of different sizes, which drive a tin roller, the larger wheel being used until the spool is half full, then that is thrown out of gear and the smaller one is thrown in gear. The traverse motion is worked by a heart wheel." This is practically the only patented invention relating to the ordinary winding frame up to 1860. The two speeds or sizes of driving wheels were required, the first or larger to get sufficient speed whilst the tubes of the bobbins were bare or did not contain much yarn. As they filled they would take up the yarn much more quickly, more quickly, in fact, than its quality at that time warranted, and so would cause too much breakage for the winders to keep their ends up. A reduction of speed would moderate this. These have long ago been discarded, and high speeds of the spindle attained and maintained, which give a gradually accelerating draft of yarn, as the periphery speed of the bobbin increases from the successively added layers of yarn. The heart cam, which actuates the yarn traverse rail and distributes the yarn evenly upon the tube of the bobbin, was an important invention, and is retained in some winding frames to-day. It is this which imparts a barrel shape to the filled bobbin of yarn.

Winding machines or frames, as they are ordinarily called, and which are intended for the usual processes of manufacture, are about the simplest machines in the whole of the cotton trade. One of the most modern type is shown in the illustration, fig. 152. In size they are made according to requirement, and differ but very slightly in

construction from whatever machine-making establishment they may come. It consists of an oblong frame, and really constitutes a double machine, being furnished with two sets of spindles on each side. This is dictated by economical considerations, as the working parts will drive two sets of spindles as well as one, and at only a small additional consumption of power. The two rows of the spindles on each side are arranged in zigzag, or diagonal order to each other, the gauge being about five inches. This order is adopted to utilize space, and to secure clearance for the spindle driving-bands.

The driving-shaft extends along the length of the frame carrying the fast and loose pulley at the headstock end. There is also mounted upon it a tin cylinder, about seven inches in diameter which extends the length of the frame. This drives the spindles, the power being transmitted by cotton bands which pass around a small pulley or wharve. The bobbin rests upon a disc plate carried upon the spindle, and its weight gives all the friction necessary to secure rotation, and to overcome the drag of the yarn. The operative passes steel skewers through the holes left in the cops of yarn by the spinning spindles, which are then placed in the cop-holders. These are carried upon a rod extending the length of the frame, and are placed in this at such an angle as to admit of the easy draft of the yarn. This in its course to the bobbin passes over the board shown at the front and generally called the knee-board, an incorrect name if regard be had to its function. This board is usually covered with flannel, and forms a check upon the too easy delivery of the yarn to the draught of the spindle, thereby securing uniformity of tension in the winding. It is therefore really a drag or tension board, and so should be called. The wire loops inserted into the bottom of the board are merely to keep the threads apart, and to prevent entanglement in cases of breakage. Passing this, each thread goes through the bristles of the clearer brush, shown by the long dark line

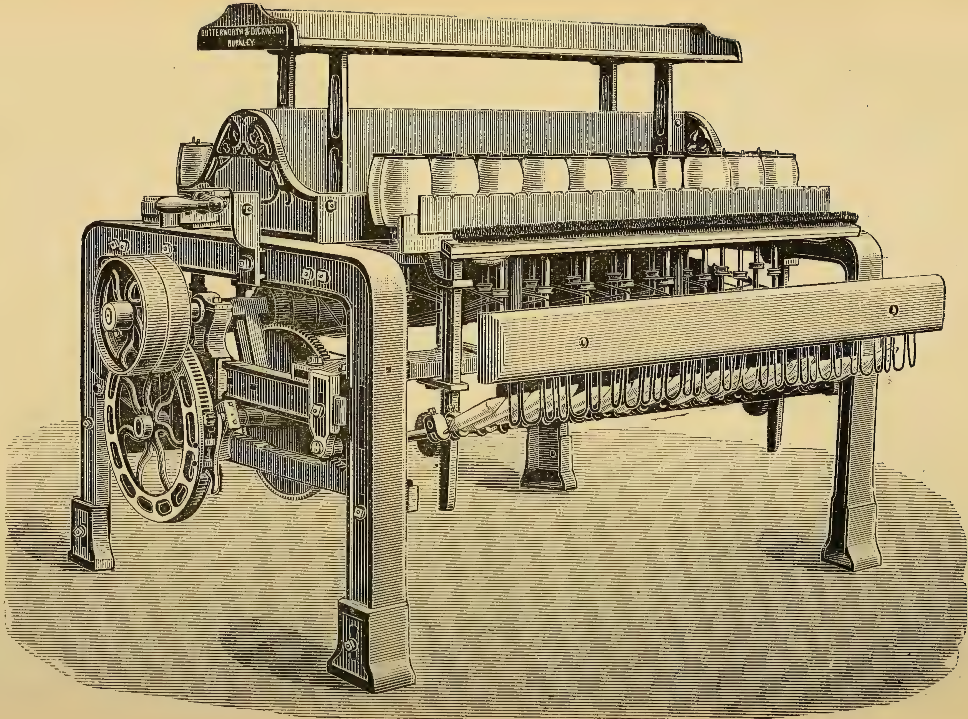


Fig. 152.—Cop Winding Machine.

above the drag-board. The function of this is to clear the yarn from loose fibres, seed leaf, etc., and to break the yarn down in soft and single places, so that these may be taken out at this stage. The meaning of these terms will be explained further on. This at one time was a most important function of this brush, but owing to the great improvement made during the past fifteen or twenty years, it is not now nearly so much required. In fact, it might, so far as single and soft places are concerned, be almost dispensed with.

Immediately the yarn has passed the brush it is received by a guide-plate, which, besides guiding the yarn to the bobbin, acts as a snarl and knot catcher or detector. It contains a series of slits, one for each spindle, and equidistant. It is generally called the "crowfoot" guide-plate, because the vertical slits which receive the threads have two branch slits made from them, one to the right and the other to the left, and inclined outwards; the whole presents a distant resemblance to the extended foot of a bird. It has already been shown with what facility the operatives in the machine shops and mills resort to nature for object names in connection with machines, rather than to the terms of mechanical science; this instance affords another illustration, and there are many more. The purpose of these diagonal cuts is to retain the threads in their proper slits when once placed there. Without these they would occasionally escape and become entangled with the others.

The brush and guide-plate are secured together, and thus form a horizontal rail which is mounted upon vertical iron bars, or rods, usually termed lifting pokers, which slide up and down in suitable brackets. Each of these has at its lower extremity a small foot or horizontal projection prepared for connection with a chain by which the traverse of the guide rail is effected, and the yarn properly distributed upon the bobbin. This is usually so arranged that the bobbin, when filled, becomes of a barrel shape.

The lift extends from flange to flange of the bobbin, a distance generally of five and a half inches. The speed of the traverse rail is not quite uniform, slightly diminishing about the middle of that portion of the bobbin by which that part receives more yarn, and thus gradually fills into the desired form.

We have called the winding-frame the simplest machine in the series used in the manufacturing division of the trade. Though this is true, it usually contains, as now

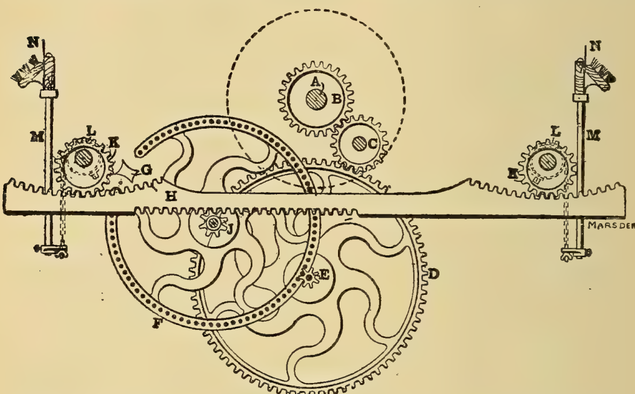


FIG. 153.—MANGLE WHEEL MOTION IN WINDING MACHINE.

generally made, a most ingenious mechanical arrangement which, for the sake of the student, may be described. This is called the mangle-wheel driving system, and is illustrated in fig. 153. It is shown apart from the machine frame for the sake of clearness.

Upon the driving-shaft, A, is mounted a spur-wheel, B, which drives through the carrier-wheel, C, the arm-wheel, D. On the same stud as the wheel, D, is the reverser pinion, E, which engages with and drives the mangle-wheel, F. This wheel is composed of two sides, which we may term imperfect rings, as they are not complete circles.

These are united by a series of pegs set in close gauge, and shown by the small circles on the wheel, F. Where the circle is broken a stop-block, G, is introduced, set a little back from the ring.

This wheel is a remarkable one, constituting as it does an external and an internal wheel, otherwise a wheel that will gear with a driver either on its outer or inner circle. In the use made of it in this instance both circles are utilized. The effect gained when the change is made is a reversion of its revolution, which is what is required. As the pinion, E, revolves, the wheel, F, is driven by it until the break in its periphery comes round to the pinion, E, when the block stops its further progress, whilst the pinion, E, forces the wheel, F, to admit it to its interior, where, then being in gear with the interior circle and revolving in the same direction, it reverses the revolution of the wheel, F, which is then driven in the new direction until the break in its circle again approaches the pinion, E, which again encounters the block, and runs this time to the outside as before it did to the inside, and then rotates the wheel in the first direction. These movements are continuously repeated.

The use of the reversing motion thus obtained will soon become apparent. The pinion, J, which revolves in the mangle-wheel, F, as will be seen, gears into the rack, H, the circular movement of the first becoming transformed into a horizontal movement of the second. As the revolution of the wheel, F, changes, so does the direction of movement of the rack.

It will be observed that each end of the rack on its upper surface is constructed to form a segment of a circle, each being furnished with rack teeth, which engage with the wheels K K, and in their traverse partially rotate them. The wheels, K K, are eccentrically mounted upon the lifting shaft, L, which extends the length of the frame and carries a number of chain blocks placed at intervals throughout its length. To each of these a chain is

attached, which at its opposite extremity is linked to the foot of the lifting pokers as previously mentioned, and thus is completed the circuit by which the movement of the traverse rail and the wind of the bobbin is connected. It only remains to state that the object sought by mounting the wheels, K K, eccentrically is the variation in the rate of the movement of the rail which gives the barrel formation to the bobbin. The diagram shows the position of the various parts represented at the time when the rail is about midway of its traverse.

This variation in the traverse can also be obtained in several other ways, as, for instance, by mounting the pinion, J, eccentrically on the mangle wheel stud instead of the wheels, K K, as shown here. Again it may be had by making the pinion, J, drive the rack, H, through two eccentrically mounted pinions.

The introduction of ring spinning on a somewhat extensive scale during the past twenty years has revealed the desirability of modifying winding machines to adapt them to meet the altered conditions, the principal of which is that the yarn has to be wound from the ring bobbin, from which it comes more freely than from the mule cop. In some cases the creel or bank in which the ring bobbins are mounted is furnished with ring spindles arranged at a slight angle from the horizontal position. The yarn is then drawn off from the side instead of from the cone of the bobbin, the drag resulting being sufficient to secure delivery at a uniform tension.

In fig. 154 is shown an improved frame for winding from ring frame bobbins, in which the ring bobbins are arranged horizontally and the yarn drawn off at the nose or cone. The speciality in it is that there is a tension wire placed at the front of the nose, through which the yarn has to pass immediately it gets off the bobbin. This secures uniformity of tension in the winding and obviates the necessity for the presence of the drag-board as shown in fig. 152. The illustration also shows a good view of

the driving end of the machine and its gearing. Here it will be seen the rack is of a different construction, and is carried upon bowls in order to diminish the power needed to actuate it. The variation of the movement required for the traverse is also obtained in a simpler way than as shown before, being got from a slight eccentricity in the mount of the pinion driving the rack. This eccen-

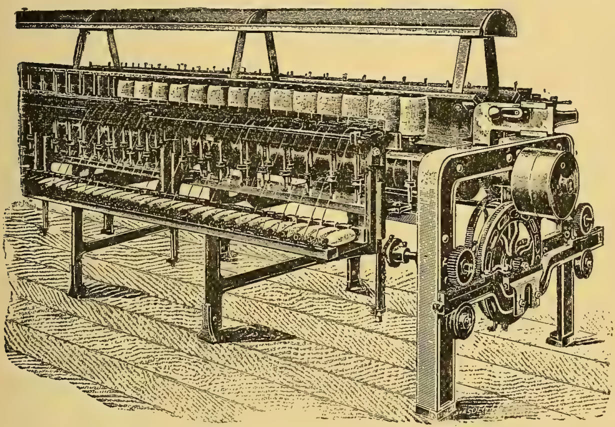


FIG 154.

tricity is so small as not to be discoverable in the illustration.

The above types of machines are in almost general use throughout the great weaving districts of North-east Lancashire, and in others where similar plain goods are manufactured, or such fancy goods as do not need any preliminary treatment, such as bleaching or dyeing of the yarn previously to its being woven.

In many places, however, what is called the coloured goods trade is the staple industry. This prevails in Rochdale, Heywood, Radcliffe, Farnworth, Swinton, Newton Heath, Failsworth, and a few other smaller places. In

these a large proportion of the yarns used, both warp and weft, have to be bleached or dyed, mostly the latter, before the weaving process. In these cases the winding process is changed for what is termed reeling. The yarn, instead of being wound upon bobbins from the cops or ring bobbins, is wound upon reels, and when doffed is in the loose form of hanks and in a condition to easily admit of dyeing or bleaching as may be required.

An improved reel is shown in the illustration (fig. 155). This reel, or others of similar type, is in use in almost every mill where reeling is required. It will be seen that the frame is a very light one, being composed of two ends made of iron, and the cop creel of wood, and a second bar just beyond it carrying the yarn guide-wires. The reel proper is a hexagon composed of six bars of wood carried upon arms loosely mounted upon the horizontal shaft shown. A circuit of this hexagon is fifty-four inches, the hank being generally reeled in that length, though sometimes in seventy-two inches. The method of driving is shown, and is so simple as to require no description. The reel being in its normal form of a hexagon has the threads attached by the reeler, as the attendant is called, the reel is started, and the yarn reeled in hanks of 840 yards. In straight reeling the hank is divided by ties into seven leas of 120 yards = 840, this being mostly the case for the eastern trade. When the hank is completed the arms of the reel are pressed together, as shown in the illustration, and the hank slided off at the end. The speciality in the machine shown is in the facility it affords for doffing.

In fig. 156 is shown the Coleby reel. As compared with ordinary reels it presents some considerable differences in appearance. The first alteration shows that the frame of the machine has been dispensed with, having been substituted by a central stand, the reels projecting from this on each side. This change permits much freer use of the space beneath the frame, and facilitates doffing

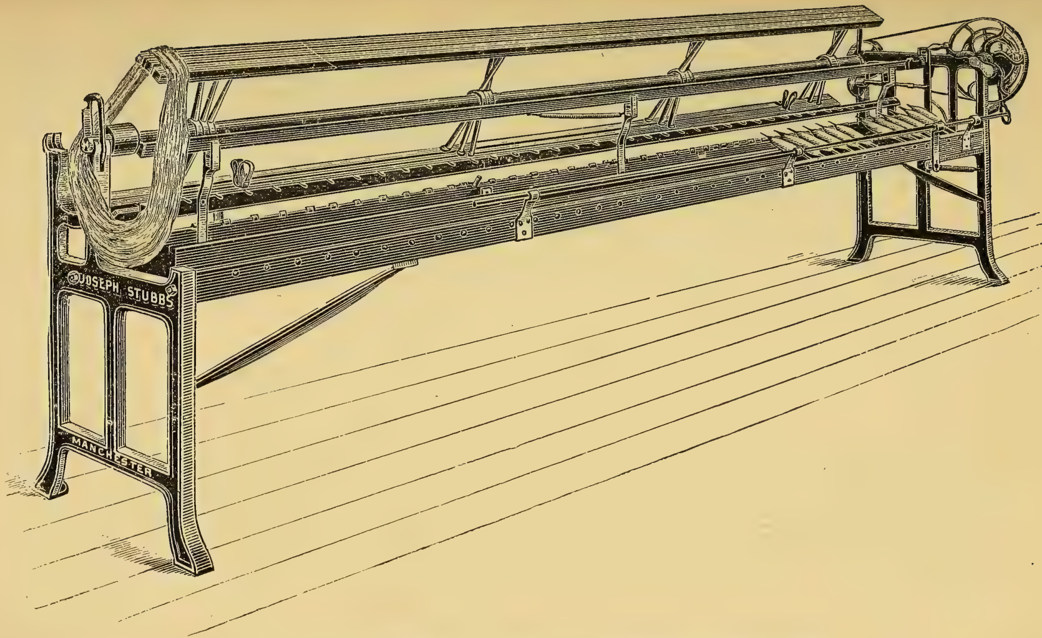


FIG. 155.—IMPROVED YARN REEL, REELING FROM COPS.

very greatly. One shaft drives the four reels upon one stand, through and by means of two short shafts carrying a pulley for each reel. On each extremity of these shafts is a small driving pulley from which the reels are driven by a fast pulley upon the axle of each reel. There is no loose pulley, as the reels are driven by means of a slack strap, which has its tension adjusted to drive the reel by means of a small bowl carried upon the extremity of the starting lever; this lever also carries a brake which is put out of action when the reel is started, and brought into work when it is stopped. By this simple arrangement the starting and stopping of the reel is instantaneously performed with the greatest ease. The speed of the reel is also regulated by the same means, as when the strap is brought to a proper tension it runs at full speed; at half tension it runs slowly in order to permit of the winding off of cop bottoms with more ease. It ought to be added that the machine can be readily changed to reel from either cops, bobbins, or tubes. Some important advantages result from this arrangement. Each section being separately driven, only one containing ten ends is stopped at a time for "setting-in," "piecing-up," or "doffing," instead of forty as in reels of the ordinary construction. This yields a very considerable gain in the production. By an improved manner of laying in the yarn this is done more quickly, and a further gain made. The skill and strength required are both less, and children can easily perform the work that previously required skilled adults. As compared with the old type there is a saving in cost, in space, and in wages. As will be seen, it is adapted for winding from cops, and ring-frame bobbins, or can be made for throstle bobbins and for the reeling of hard-twisted yarns, as seen in fig. 157. In the latter form it is supplied with an excellent tension adjuster, also the invention of Mr. Coleby.

Reeling for the home trade is often done in the spinning-mills, and in most cases it is of the kind called "cross

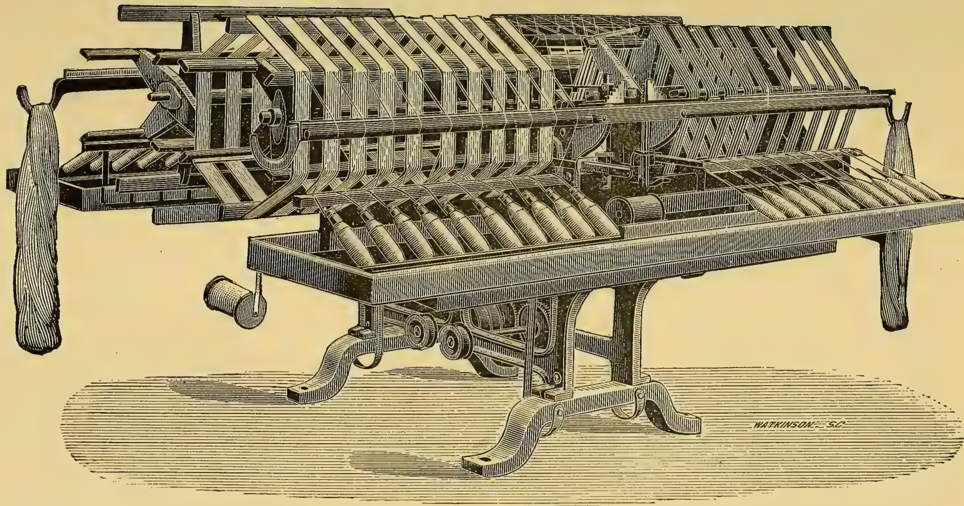


FIG. 156.—THE COLEBY REEL REELING FROM BOTH COPS AND RING-FRAME TUBES.

reeling;" that is, the threads are rapidly traversed in a lateral direction backward and forward, so that they never lie parallel to each other, but rather diagonally across each other all through the hank. The object of this is to ensure that in the event of a thread breaking the end shall be soon and easily found as it always lies upon the surface, which would not be the case were the system of parallel winding used. Thus much loss of time is prevented, in the first place to the reeler, and in the second to the hank winder in the subsequent process of winding from the hank after bleaching or dyeing. The advantages of cross reeling seem to be appreciated mostly by the home and continental trades, as in yarns for exportation to the great eastern markets, straight reeling seems invariably adopted.

Cross-reeled yarns for the home trade are made up in long bundles and are not pressed, as are straight-reeled bundles, for export to the east. It sometimes happens that in a manufactory reeling its own yarns that its capacity of production may occasionally exceed that of the consumption of the establishment. In these cases it sometimes becomes economical to turn the reels upon straight reeling and sell the yarn. In this case there will be required a short-bundle yarn press such as that shown in fig. 158, a very excellent automatic press invented by the gentleman whose improved reel has just been described.

Ordinarily the yarn bundling press consists of a small oblong table and a number of vertical bars affixed against each of the longer sides, so as to enclose on two sides a cubic space, the ends being open. To the back bars are attached a third series, hinged to them, so as to be brought over to those in front. The yarn having been placed in position, the covering bars are brought down and the table raised by the usual means, the motive power being either manual or steam-power, which may be most convenient. The yarn having been pressed, the press is wound down, the bars lifted, and the bundle taken out. This is the

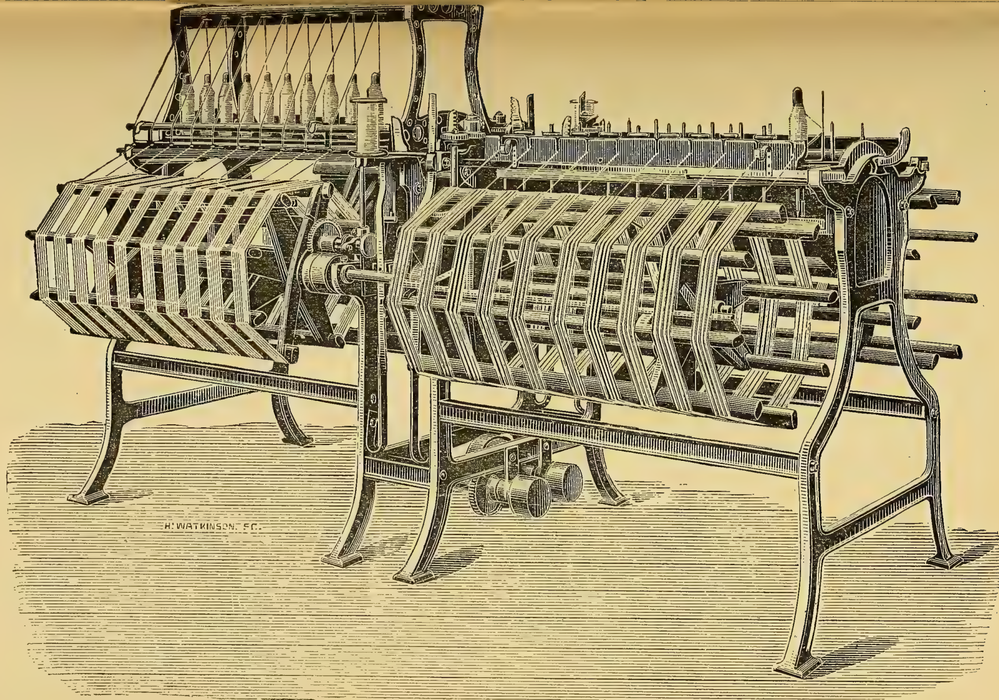


Fig. 157.—The Coleby Reel. Adapted for Ring-Frame Tubes and Doubling Bobbins.

ordinary method, upon which Mr. Coleby has effected great improvements, as he has made the whole automatic, so that when the yarn has been placed in position the attendant has only to start the press, and the bars are automatically brought down, self-locked, and the bundle pressed, when the attendant simply ties the cords and reverses the action, and the press, running down, releases and lifts the top bars, leaving nothing more to do than to remove the bundle and commence the process anew. The improvements consist of the introduction into the back vertical bars, which are made hollow for the purpose, of a series of rack rods, whilst the top bars, also made hollow, receive a corresponding series of locking rods. A connection is formed between the two series by means of a sector wheel. When the top bars are brought down into the position for pressing, a coiled spring, with which each is supplied, shoots these rods into the holes prepared for their reception, and thus firmly locks them for pressing. When the action of the press is reversed these are withdrawn by the descending rack rods acting through the sector wheels. By means of this improvement considerable economy is effected, as the labour of boys suffices where previously that of men was required.

If the yarn reeled as described is for bleaching or dyeing upon the same premises it is not necessary to bundle it in any form, but simply to pass it forward to the bleaching or dyeing departments. If the yarn is sold in the bundle for the home trade it is usually made up in long cross-reeled bundles; if for export, in short pressed bundles, that may be either straight or cross-reeled. Whichever be the method, it is ready for the bleacher or dyer, or for re-winding in the grey state which is often done with yarn exported and sold to the handloom weavers of eastern countries in retail quantities.

To the processes of bleaching and dyeing a brief separate chapter must be allotted, which will be found following the present one.

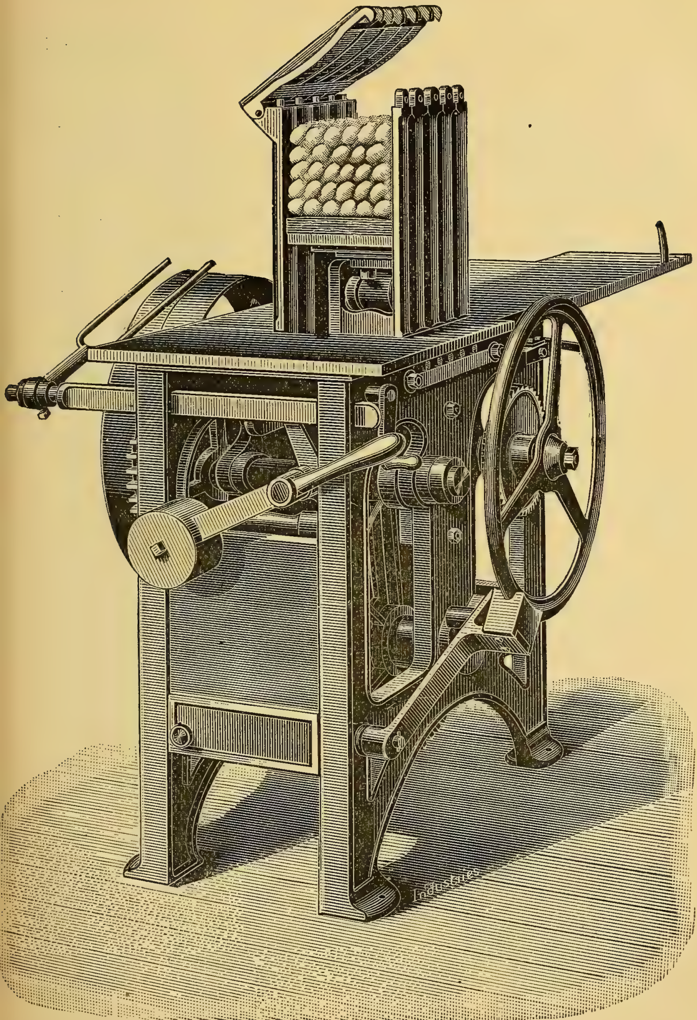


Fig. 158.—Improved Yarn Bundling Press.

Assuming that it has passed through these stages, and been returned to the winding department, the description may be resumed at the point left off.

The yarn is now ready for re-winding, and for this purpose a winding machine of another type is usually adopted. This is termed the hank-winding machine, and one of these of the latest and most improved type is shown in fig. 159. It is especially made for winding bleached or coloured and sized yarns from the hank. As will be seen, its construction is entirely different from that of the simple cop-winder. The bobbins, instead of being mounted upon vertical spindles, are carried in cradles lying horizontally. Upon the driving-shaft, which extends across the top of the frame in the direction of its length, are mounted a number of bobbin-driving drums. The cradles, having received their bobbins by suitable arrangements, carry them into contact with the faces of the revolving drums, which thus drive them by friction. The hanks are placed upon light, collapsible hexagon reels termed rices, which are easily lifted out of their position for the reception of the hank. They are very light, and easily revolve with the pull of the thread. This is termed the rice creel. There is an alternative creel termed the barrel-creel, formed by two small skeleton barrels, or bird-cages, as they are sometimes called. These are seen in fig. 159, the creel on the back of the machine being of this type. The bottom barrels only are shown; each of these has a corresponding barrel mounted above it, and the hank is extended between them, and so wound off as in the other case. In the winding the yarn is slowly traversed from side to side of the bobbin so as to place the successive layers evenly upon it.

In the machine here illustrated are a number of improvements which it may be desirable to point out. The first is in the bobbin cradles, which are mounted on brackets attached to a rail placed within and extending the length of the machine frame. Each cradle is fitted with a new

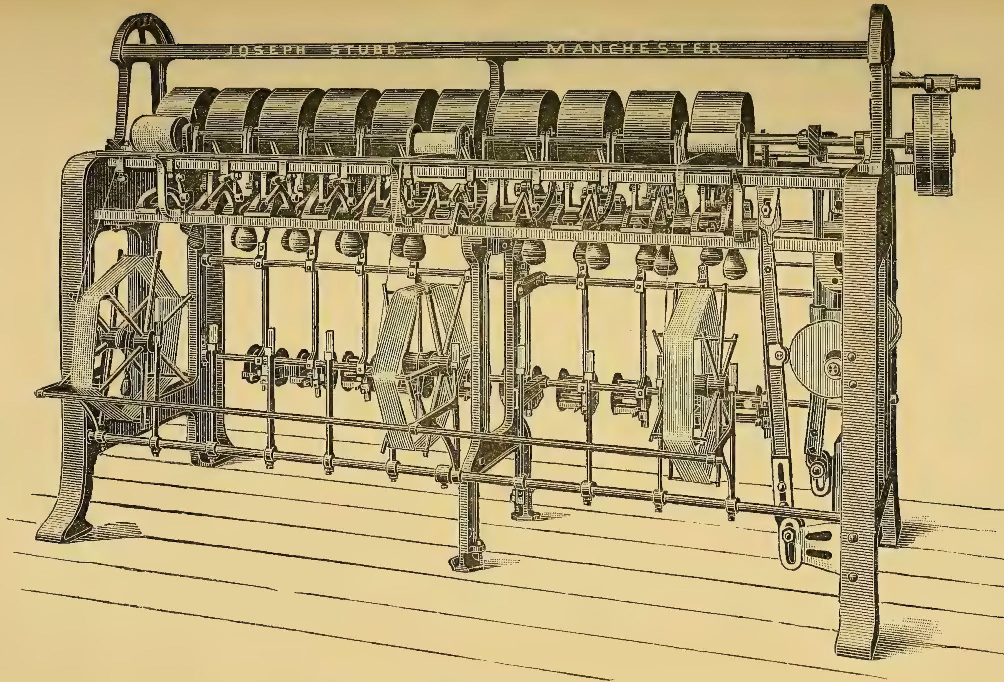


FIG. 159.—IMPROVED HANK WINDER.

setting-on handle, by means of which the attendant can bring the bobbin very gradually in contact with the driving drum, instead of its being allowed to tumble against it. The jerking start made with the last-named method very frequently breaks the threads again, especially when tender and fine yarns are being wound. By the improvement described these breakages are avoided. Another is the introduction of an adjustable weight, which is carried upon a lever attached to and projecting backwards from the bobbin cradle. This is a novel application, so far as this type of machine is concerned, and by its means the pressure of the bobbin upon the drum can be made heavy or light as may be desired. An improvement has also been effected in the gearing through which the traverse motion is actuated, which renders the driving of the traverse very simple and noiseless. This consists of the introduction of a pair of helical wheels instead of the bevels ordinarily employed for transmitting power from the drum shaft to the short horizontal shaft carrying the heart cams. The connection between the vertical and horizontal shaft is effected by a worm upon the bottom of the former, which gears into a worm wheel on the latter. This driving arrangement obviates the noise and back-lash incident to the ordinary method. The traverse lever is made adjustable in length so as to easily yield any length of traverse as required. An improved strap fork and starting arrangement has also been introduced. This consists of a handle carrying a small pinion which is attached to the base of the fork. The latter is mounted upon a stud in such a manner as to slide backward and forward. The under part of this stud forms a rack into which the pinion gears, and thus by means of the handle the fork is traversed with ease from one pulley to the other as required. Its great merit is its adaptability to any width of pulley, and the facility with which it can be made to govern the length of the traverse of the strap. The rice creel is made of iron, and the rices are mounted

upon a round shaft extending the length of the frame instead of being dependent from the upper parallel rail as before. This ensures easier adjustment whenever such may be needed. The adjustable barrel creel, shown on the opposite side, is also made in an improved manner. The top barrel is fixed, the bottom barrel being carried on a centre, and is adjustable for various sizes of hanks.

The principles, purposes, and the earlier forms of warping have been sufficiently explained, the first need only here be summarized as the laying in parallel order of the yarns intended to form the length of the woven fabric when intersected with its weft or cross threads.

The invention of the dressing and sizing machines, the latter especially, necessitated a radical change in the system of warping for the manufacture of ordinary plain goods. This came in the invention of the beaming machine, which appears to have been the product of the inventive skill of Thomas Johnson, of Stockport, who endowed the trade with the dressing machine. The beaming machine was a necessity of the dressing machine, and its invention was, therefore, an adjunct of it. It is described in his patent for the dressing machine granted February 28th, 1803. Little improvement appears to have been made in it until the invention of the now well-known "warping-frame," as it was called, which in Patent 9660, March 11th, 1843, is credited to William Kenworthy, then manager of Brookhouse Mills, Blackburn. The latter machine was a great commercial success. It consisted of a creel holding about 400 bobbins, a frame containing a coarse open reed, and beyond these, in the direction of the beam, a series of iron rods so mounted in the frame that they could be made to fall and reverse the revolution of the beam, delivering back the warp to the extent of several yards when a thread had broken, in order to permit of its being taken up and pieced. This facility gave this invention its great superiority over anything previously in use. The machine contained a large

wooden cylinder mounted upon the driving shaft, and on this the warper's beam rested, being driven by the friction surface contact. Thus whatever might be its diameter a uniform speed was maintained, derived from the driving cylinder.

This invention sustained its pre-eminence during its existence as a patent, and for ten or fifteen years subsequently. Afterwards it became the subject of further improvement in details, and a number of these were introduced which may be passed with merely the mention of the expanding reed, or comb, introduced to facilitate the distribution of a small number of ends over the barrel of a wide beam in order to avoid the necessity of moving its flanges nearer together. Another was to mount the "falling rods" upon their centres, so as to diminish their friction and ease the passage of the yarn over them on its way to the beam.

Not much of real improvement, however, was effected until the invention of the automatic stopping motion, which stopped the machine immediately on the breakage of a thread. There are two claimants for this invention, William Rosseter and Thomas Singleton. The first-named appears from the records of the Patent Office to have been the first in the field with this idea, which the latter improved upon, and finally got the chief credit and reward of success, owing to the superiority of his invention. The machine known by his name is now in almost universal use where beaming machines are required. Its most modern form is illustrated in figs. 160, 161. Only a brief description is necessary.

The machine, as will be seen from the illustration, fig. 160, consists of two principal parts, the creel and the headstock. The creel is the frame which contains the bobbins as they come from the winding machine. It has two sides, which are arranged or placed together in the form of the letter V, with its apex towards the headstock of the machine. In the back of the headstock, near the apex, stands a coarse open reed, A, fig. 161, through which

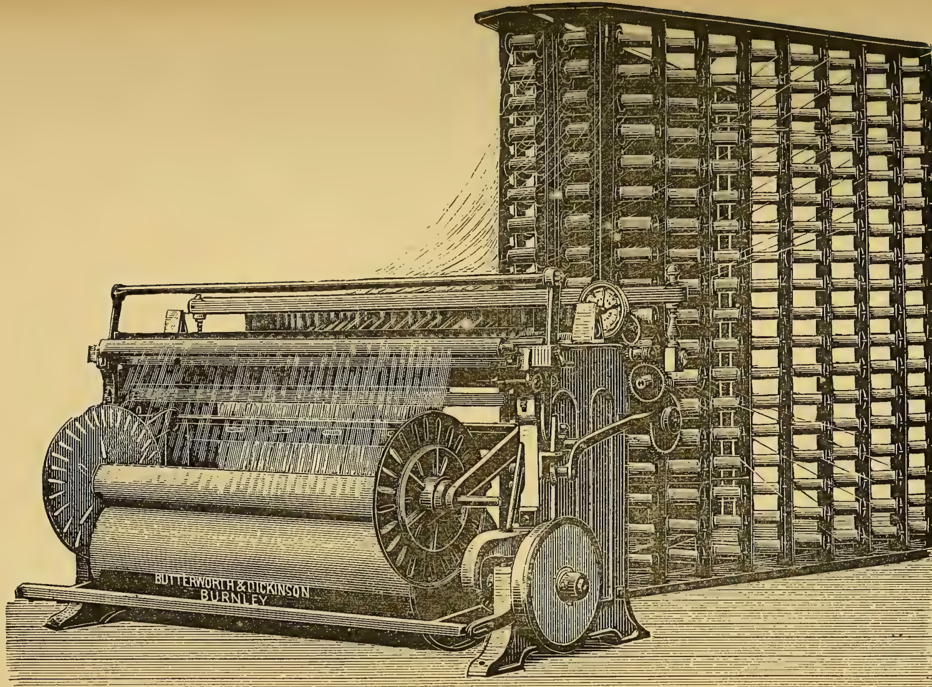


FIG. 160.

the yarn from the bobbins is brought. Passing over the carrier roller, B, it descends under the first drop or reversing roller, C, over another carrier, D, and under the second drop roller, E. Two drop rollers are all that are required since the invention of Singleton's automatic stop motion. Formerly there were six, or any other number deemed sufficient to meet requirements. Leaving the second drop roller the yarn passes over another roller, F, which besides being a carrier, has the more important function of measuring the length of yarn that passes, and hence is termed the measuring roller. All these rollers are tin cylinders. From the latter the yarn goes forward over a plate or bar, G, containing three slots of about one-eighth inch wide, which extend across the width of the machine. Each thread has a small bent wire, about $1\frac{1}{2}$ inch in length, hung upon it at this position, the ends of which descend into the slots in the bar beneath, and by them are retained in position. Leaving here the yarn next passes through an expanding comb, H, and thence over the carrier roller, J, to the beam, K. The comb, H, is so constructed that it will expand or contract by the turning of the screw, H, of which there are two, one at each end. These are furnished with a hand wheel, as shewn. The purpose of this expansion is to evenly spread the yarn over the beam between the flanges to prevent its forming ridges and hollows which strain the yarn, or cause it to run slack in being drawn off in the sizing process, and both of which would produce undesirable results.

The mechanism may now be briefly described. Extending across the front of the machine is the footboard, L. This, when starting the machine, is pressed down by the foot of the attendant, and at a certain position is held by a spring handle entering a detent upon the frame. The driving shaft, M, has fixed upon it a friction plate, N. Next thereto is the pulley, P, which is loose upon the shaft. Beyond this is the loose inclined collar, R, which

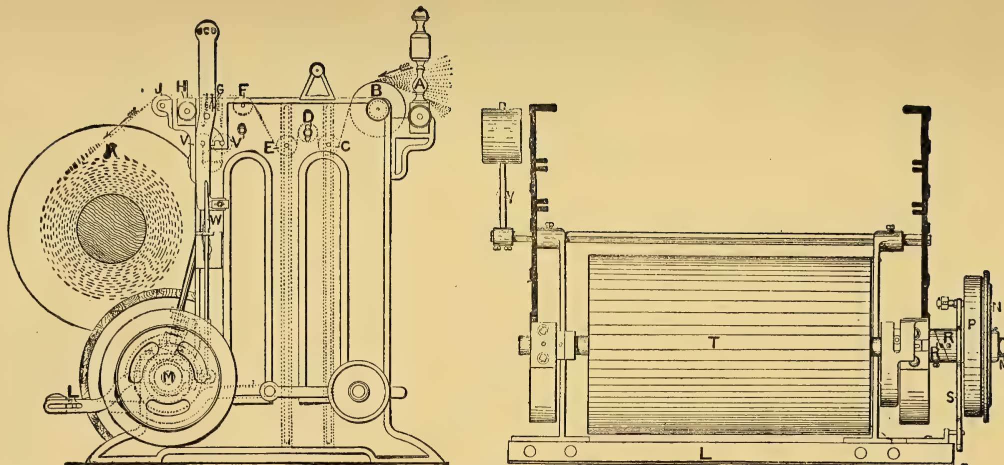


FIG. 161.—BEAMING MACHINE; SIDE ELEVATION; PLAN.

is set against the corresponding incline, R′, made fast upon the shaft. The inclined collar, R, and the footboard, L, are connected by the lever, S, which is fast upon the loose collar, R. When the two inclined collars are in the position shown in the figure, the pulley, P, runs loose upon the shaft and the machine is stopped. When the machine is started the loose inclined collar makes a partial turn, so as to close up the hole shown near the letter R, and in doing so it also slides laterally upon the shaft pressing the pulley, P, against the friction plate, N, which being fixed, becomes the driver and starts the machine. The wood cylinder, T, being fast upon the driving shaft with the beam, K, resting upon it, drives the latter by frictional contact.

We now come to the automatic stopping arrangement. The drop wires or pins hanging upon the threads on the breakage of any of them, or the exhaustion of a bobbin, the wire belonging it instantly falls between the two rollers, V V′. These are termed the nip rollers, one of which is mounted in loose bearings. When a pin falls it is drawn between the rollers, and consequently presses the loose one, V′, away from its fellow. The lateral movement of the loose roller pushes the spring handle out of its detent, reverses the movement of the inclined collar, R, relieves the pressure upon the pulley, P, which then runs loose, and stops the machine. The weighted lever, Y, is simply a balance for the footboard or treadle, L. In the rare event of the machine not being responsive to, or the stopping arrangement being slightly delayed in its action, which can only occur when the pin slots have an accumulation of waste down upon them which impedes the drop of the wire, the end of the broken thread is drawn upon the beam. To recover it the machine is stopped, and the winding reversed by means of the drop rods, until the end of the broken thread is recovered.

The beaming machine is fitted with a very accurate measuring motion, to insure a correct register of the

length run upon the beam. It is necessary the length should be correctly known and controlled in order that sets of beams may be made of any required uniform length, and when combined and worked off in the sizing machine, that they should finish all together. Were it otherwise the yarn left upon any or all the beams after the first had run off would be wasted. It is also desirable to prevent waste occurring in this manner, that the yarn shall be worked in all the beaming machines at a uniform tension, and that as light as possible. In fact, in all the processes of manufacture preceding the weaving, it should be regarded as a cardinal principle that the yarn should never be stretched, or in any way have its elastic strength drawn upon, as this is strained to the utmost in weaving.

The attendants upon these machines are females, who are generally termed warpers. It should be observed, however, that the beams made upon it are not warps, but merely longitudinal sections of warps, as it requires generally from four to six of these beams combining and their contents being run off together, to form a warp. The beams usually contain from 400 to 500 threads, and as many of them are combined in the creel of the sizing machine as will give the requisite number to form the fabric required.

The length of the yarn run upon these beams is generally stated in "wraps," this being the name given to one complete circuit of the measuring mechanism upon the machine. This consists of the measuring roller, F, the circumference of which is 18 inches. Upon the axis of this roller is a worm gearing with a wheel containing 54 teeth; on the stud of this wheel there is fixed a second worm wheel, containing 132 teeth. The first worm takes a tooth at each revolution of the measuring roller, which represents half a yard; a complete revolution of the first wheel into which it gears represents the passage of 27 yards. One revolution of this wheel represents the

movement of a tooth only on the second wheel, and as the latter contains 132 teeth, and one revolution of this is required to form a wrap, it follows that a wrap upon this gearing contains 3,564 yds. A beam generally contains four or five wraps, equal to 14,256 yards, or 17,820 yards respectively. The length of the wrap varies according to the details of the gearing, of which there are several. Assuming that the beam contains 500 ends, and that five of this kind are combined and run off together, they will form a warp or weaver's beam, containing 2,500 threads, which set in a 60 reed taking 60 threads per inch, would fill a width of 41·66 inches. Allowing for contraction this would make a cloth full 39 inches wide of 16 threads per $\frac{1}{4}$ inch. Taking the greater length of 17,820 yards, and dividing it by 40, the length of warp usually allowed to make a $37\frac{1}{2}$ yards Indian shirting, contraction thus being allowed for, the set of beams from the beaming machine would thus give 445·50 pieces. These would make 20 or 21 warps for the weaver's loom of 22 or 21 pieces each, which is the number usually put upon a loom beam.

In the coloured goods trade another method of warping is needed, owing to the large assortment of patterns required by dealers in these classes of goods and the small number of pieces of each. A set of warp beams such as are used in the plain cloth trade just described would be quite beyond the requirements of the market. The warping must therefore necessarily be done in small quantities of the selected patterns, the result being that special machines designed for the purpose must be called into requisition. The old-fashioned warping or reel mill already described was in use in this branch until within about twenty years ago, when it was superseded by an improved machine termed the section warping mill, which gave the manufacturer great facilities compared with those of the old reel machine. In fact, work can be done with ease and cheapness in the way of varying patterns, that

on the old plans would have been almost prohibitive on account of cost. On this machine the patterns, whatever may be their variety, are made by the use of a creel containing about 250 bobbins or other numbers required to form a complete pattern or part of a pattern, and then making as many small warps, called sections, as are needed to complete the width of the cloth to be made and the

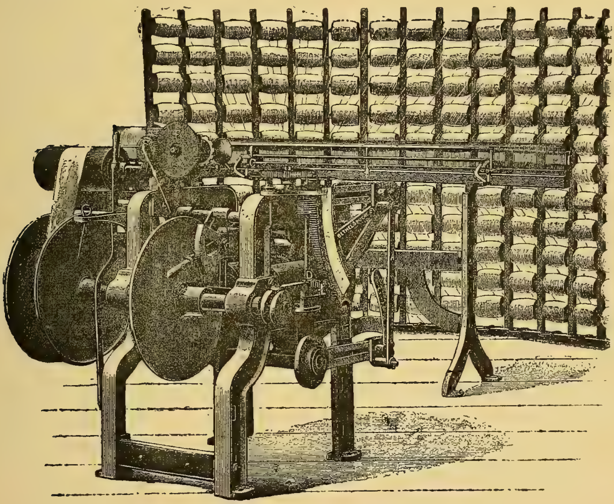


FIG. 162.—SECTION WARPING MILL.

number of patterns it will contain. When this number of sections has been made, they are put together on a common spindle and wound therefrom upon the loom beam.

The machine is illustrated in fig. 162, and consists of parts almost identical with or equivalent to those of the beaming machine already described for plain goods. The creel, which is here represented as semicircular, may also be of the V form. It is usually made to contain about

250 bobbins. From these yarn passes through the wide reed shown. In some cases the automatic stop-motion on the Singleton principle is introduced at this point, but this having already been described it has not been deemed necessary to introduce it again. The yarn next passes to a condensing or contracting reed, partly seen behind the roller over which the yarn is shown as passing. This reed is constructed in two pieces, which are hinged together in the middle, and so made to open and close somewhat like the covers of a book when set on end. It is opened or closed to such an extent as to bring the yarn into the compass of and evenly distribute it over the diminutive beam termed the section-block, upon which it has to be wound. The remainder of the headstock consists of the necessary mechanism for winding, compressing, measuring, marking, and doffing the section warp when completed.

In working this machine the warper brings the yarn from the creel through the parts of the machine already described, runs the headstock a few revolutions without yarn, adjusts a section block between the two outer flanges, fastens the yarn in a hole made in the block for the purpose, turns the machine half a revolution, then puts in the lease cords and turns the machine another half a revolution. This brings the lease cords over the top of the measuring roller, the starting-point from which the measurement of the piece lengths must be made. There is a special piece of mechanism for this purpose termed the measuring motion. It is adjusted and connected on starting a section for marking by drawing out of gear the small double wheel, E, which connects with the wheel, F, and the worm below it; then turning the wheel, F, which is a dial wheel numbered in sections of 5 up to 100, though the figures are not given in the illustration, to the left, until the movement brings the number corresponding to the length of yards required opposite a pointer fixed below, and the highest number on

the star wheel behind, F, to the same position. Then the double wheel, E, is replaced into gear as before. The link-rod, A, is next taken off, and the toothed sector wheel, an arm of which bears the patentee's name, and the sector is wound down as far as possible by means of the handle, C, the two catches impelling the ratchet-wheel, D, being set back whilst this is done, when they are replaced. The first section warp, which usually contains one of the selvages, may now be proceeded with. A short length to form the "thrums" is first wound, which brings the number 100 on the wheel, F, exactly opposite the pointer. This movement rings the pointer bell. The cut or piece mark is then put on the yarn. The double wheel, E, is again drawn out of gear, the wheel, F, turned round in the direction in which it runs until the number corresponding with the length of the piece is again brought opposite the pointer, when the wheel, E, is replaced, and the winding of the section proceeds until it has been about half completed, when the pointer on the radial piece, G, behind the connecting link, A, must be fixed opposite to the line on the lever, H. The rod, A, must then be replaced, which is done by moving the two studs which carry it in their respective slots until the link can be put on easily without changing the position of the line on the bottom lever carrying the stud, relatively to the pointer on the radial piece, G. The work is then proceeded with until the section is finished.

The measuring motion is only required for the piece-marked section of the warp, and is afterwards thrown out of gear. In winding the subsequent sections care must be taken that the same number of revolutions are wound upon them as upon the marked section. These are given on the dial and star wheels.

The sections are easily doffed and the mechanism quickly rearranged for succeeding ones.

When a sufficient number of sections have been made for forming a warp, they are placed together on a spindle

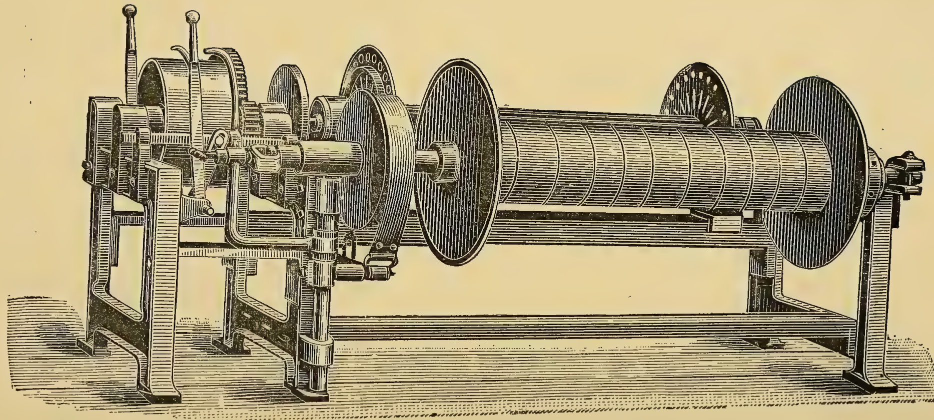


Fig. 163.—Section Warp Beaming Machine.

and wound off upon a loom beam in a running-off machine, which is illustrated in fig. 163. This is a beaming machine, and is so simple that it will be comprehended without any further explanation by those who have perused the preceding pages.

It has previously been pointed out that the old system of ball warping, even when followed for making plain grey cloths only, was seriously defective. It was much more so when the warps, before passing to the loom, had to be bleached or dyed. In either of these cases the additional handling was very liable to magnify every fault. This was so much the case, that in dyed warps, especially in beaming, the warps had to undergo a dressing process, not the dressing process that will be shortly described as being an elementary stage of the sizing of to-day, but which consists of a careful examination of the warp as it is being beamed, piecing the broken threads, taking out knots, disentangling twisted portions, and otherwise clearing the warp from every obstacle to the weaver's operations. This was a very expensive treatment, and still remains so where no improvement has been adopted.

Appreciating the serious drawbacks of the old system of ball-warping, Mr. Garstang, a Lancashire manufacturer, a few years ago invented a new warping machine for making ball warps for bleaching or dyeing purposes specially designed for obviating the difficulties encountered in the ordinary process. This is illustrated in fig. 164. In it the inventor avails himself of the large beams made upon the beaming machine for the modern sizing machine. The new machine contains a creel, A, for the reception of a sufficient number of these beams to make a warp of the required width. The lease is obtained at starting in the ordinary way, and in combining them the warp runs off perfectly straight, and perfectly free from the twisting which takes place in the ordinary system. Instead of as in the slasher sizing system, the contents of each beam being superposed on each other in succession, each sheet

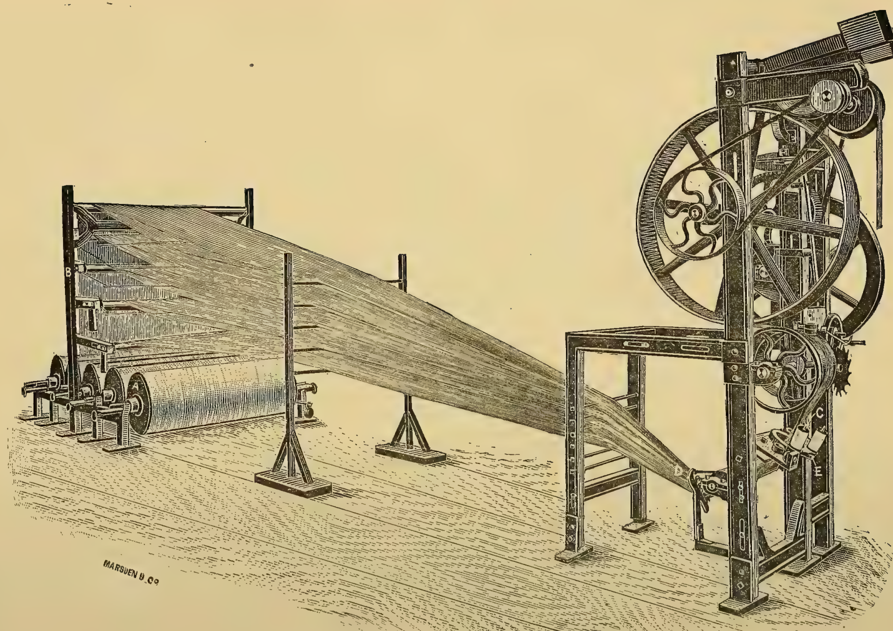


FIG. 164.—IMPROVED LOOSE WARPING MACHINE.

of threads is drawn from its respective beam over a set of three rollers, B, the middle one of which forms a tension drop roller, which automatically takes out the slack and thus aids to make the sections of perfectly uniform length. The beam creel is placed at a sufficient distance from the headstock to allow each sheet of threads to converge by the time they reach it into a narrow tape of threads, C, of about three inches width. Each of these sections is passed beneath a curved conductor, D, which lays them side by side, not upon each other. Thence the now united sections pass through a ring, just above which, and enclosing the warp, is a wheel, E, revolving upon carriers, and itself carrying a bracket upon which is placed two small bobbins of yarn. The revolution of this wheel with its bobbins wraps the warp with a binding thread which keeps it together, the turns being about one in every ten inches, or any other length as may be arranged. A turn in the above length has however been found sufficient for all purposes. The warp next passes over a measuring roller, where the piece lengths are automatically marked, thence around a pair of friction-pulleys and over a carrier roller into an open sack arranged for its reception. From beginning to end there is not a single turn put into the strand of threads forming the warp.

On the new machine a length equal to three loom warps, or say 3,000 yards, is run into one, forming one large warp. This is a great advantage in the matter of production, as it enables the machine to make long runs without stoppages, and thus greatly increases the quantity of work turned off. In dividing these warps into proper lengths the lease is "struck" with a comb, as in "slasher" sizing. At commencement and finish the leases are taken in sets of ten threads or any other number. The long warp is a great advantage to bleachers and dyers, as it almost obviates the tying together of the warps necessary for the passage in those of the ordinary length.

In point of production one of these machines will supply warps for 300 looms, weaving cloths of from 12 to 15 picks per quarter inch. One man and a boy can take charge of two machines, thus doing the work for 600 looms. The services of the boy are needed to tie up the piece-marks to prevent the obliteration of the mark in the dyeing process, as the tied-up portion does not absorb the dye. In the old ball-warping machine the warper had not only to mark the pieces by hand, but had to tie up the marks in the same manner, his mill being meanwhile stopped. In the new machine it continues at work. In the former case a large percentage of the working time is lost; in the latter it is all utilized, the boy tying up the marks as they come forward and dropping them into the sack.

It will be obvious from this description that the advantages of the new machine are very considerable in the increase of production, economy, freedom from the characteristic faults of the old system, and an absolute improvement of the work as compared with that obtained from the latter. In the old system throstle or ring-frame yarn was generally held to be indispensable, but owing to the better performance of the work in this machine mule-yarn, which is generally a little cheaper, can be substituted, and as good results obtained. Changes from plain cloth weaving to coloured work, and the reverse, can be made with facility, as up to the point of making warper's beams the processes are identical. A manufacturer can thus readily avail himself of the most profitable section of the market, as in plain cloth the only machines that would be stopped would be this warping machine and the subsequent dressing frame.

The inventor of the above machine has also displayed his skill in the invention of a new coloured warp-dressing machine, fig. 165. The frame in ordinary use is well known to those engaged in this branch of the trade, therefore little time need be spent in its description. In its

use the worker is only assisted to a limited extent by steam-power, and sometimes not at all. In the former it is only to the degree of winding the yarn upon the beam. The dresser, as the workman is called, does all the other work, which is very light, on the manual principle. The warp is placed beneath the frame, whence it is drawn through a set of tension rollers, thence over the "stangs" or winding-on poles. Between these poles and the beam is a distance of about twelve to fourteen feet, and in this space the workman conducts his operations. The warp having been separated into sections on the poles, the

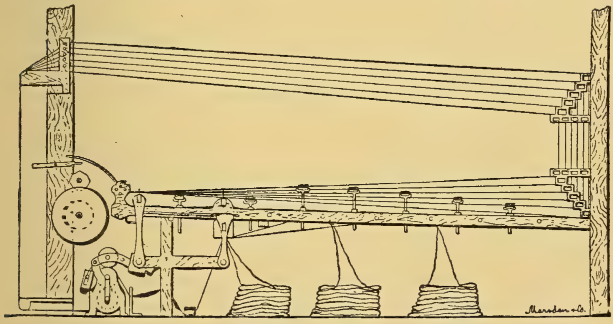


FIG. 165.—WARP DRESSING MACHINE.

dresser commences by brushing it backwards with a hand-brush, the length of which extends across the width of the warp. This brushing partially opens the warp, and removes the impurities acquired in the dyeing process. The warp is next further opened in a dressing-reed, and the threads are again more perfectly separated by the lease rods. After this it passes upon the beam.

Hand-dressing, as thus described, is a slow and expensive one, the workers earning from 36*s*. to 40*s*. per week for the performance of duties that certainly do not call for more skill than could easily be acquired by any youth or young woman from seventeen to twenty years of age,

and certainly not nearly as much as any average weaver possesses. The workmen, following practices very prevalent in the first thirty years of the century, have kept the occupation a close monopoly amongst the families and friends of those engaged in it; and so exclusive are they, that even yet in some instances they stipulate that they shall leave work several minutes in advance of the other workpeople and return several minutes later in order that they may not be compelled to mingle with the plebeians of the industry. This affords a remarkable illustration of the inconsistency which prevails amongst so many working people, even when they are asking for the abolition of all class distinction. Naturally enough where such pretensions are put forward, those who hold them may be expected to have made themselves troublesome in other directions.

It was experience of this kind which led to the invention of the new coloured warp dressing machine. In this the inventor introduces into the ordinary dressing frame two parallel bars or side rails, into which he places stands to carry the dressing brushes, which are thus, as it were, fixed, and over which the warp runs in its way to the beam. Before coming to the brush a "ravel" or "wraithe," a coarse comb, is introduced, which is suspended from cords. This substitutes the dressing reed of the older frame. The attendant moves it backward and forward to open the warp into "half beers." In this state it passes over the dressing brush. At this point we come to the principal improvement, which consists of the introduction of an expanding reed, of which the inventor also avails himself to form an automatic stop motion. This is accomplished by mounting the reed vertically upon two short standards pivoted in brackets, and kept in a vertical position by a number of spiral springs attached to a cross-rail in the frame, and to another upon the standards carrying the reed. When the warp, through entanglement or any other cause, sticks in the reed, the obstruc-

tion carries the latter forward towards the beam, and by means of a connecting rod attached to it, brings into action a catch, which through a wheel instantly stops the machine before any warp threads can be broken.

The simplicity and effectiveness of the new machine, and the perfect manner in which it has obviated the difficulties of the old one, is demonstrated in a very short time by an inspection of its working. Each of these machines will do twice the amount of work that can be obtained from the old one, whilst one man and a boy can easily superintend two, producing much better work than before. There is also a large economy in the wages paid for weaving, the work it produces ranking with "full dressed work."

There is still another warping machine which calls for a brief description. This is the chain warping, or chaining machine, as it is mostly called. The chain or linked warp is a form of warp best known in the districts where bleached and dyed fabrics are usually manufactured. Chaining is a process of linking up a long warp into such a form as to give it the appearance of a chain. This process shortens the warp very considerably, probably two-thirds, and greatly facilitates the handling in the processes of bleaching or dyeing, whilst it permits the free access of the bleaching liquor or colouring fluids to every portion of the warp. It is therefore a great convenience in these stages, and is extensively resorted to in Scotland, Yorkshire, and some districts of South Lancashire.

To chain a warp was formerly part of a warper's duty, and he who could perform it quickly and skilfully was highly valued. The lack or scarcity of these men led to the attempt to invent mechanical appliances to perform the work, but of these attempts very few came to anything approaching a successful issue. Success required that the movements of the human arm and hand should be most accurately imitated, and link up and interlock the warp in such a manner as would form a chain that

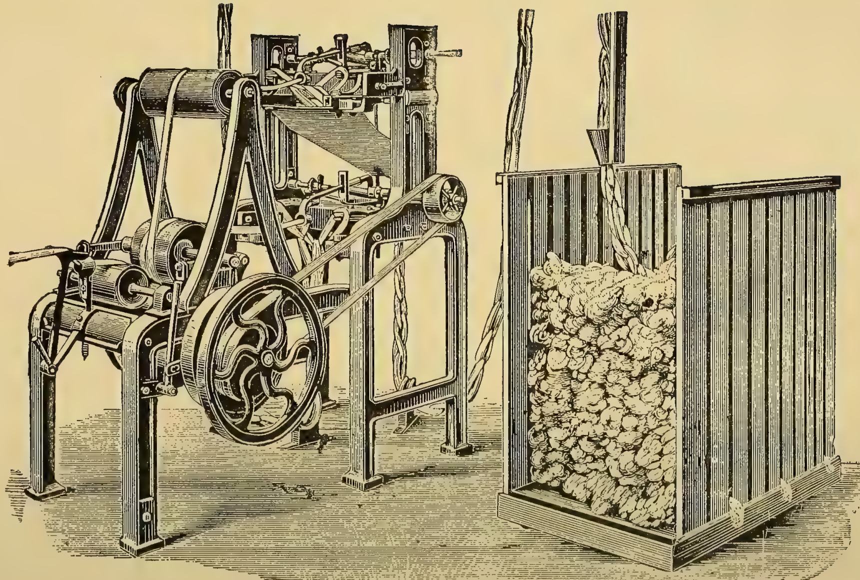


FIG. 166.—WARP CHAINING MACHINE.

should remain in that condition as long as needed, and afterwards be unlinked or drawn out with perfect ease and freedom without damaging any part in doing so.

The most, and indeed completely successful chaining machine yet invented, is that of the late Mr. William Hurst, of Rochdale, who exhibited and explained its working to the present writer a few years ago. Mr. Hurst was a cotton spinner, and in the course of business traded considerably in chained warps.

His invention, illustrated herewith (fig. 166), consists of a machine for making a double link chain or links of fine strands, by a series of reciprocating mechanical actions. The inventor fixes two projecting hooks or horns to the frame, and around these causes a trumpet-shaped guide to pass in such a manner as to carry the warp alternately around the horns. Within these horns grooves are constructed, in which are two other hooks which advance and recede. Beneath the fixed projecting horns, mounted upon the tops of two vertical shafts, are two revolving loopers, and as the trumpet-shaped guide passes around the fixed horns, the warp it is carrying is looped upon one of them. The sliding-hook in the latter then advances, and draws the warp inward along the horn. The sliding-hook is then liberated from the warp, in order to be in readiness for its next movement. Whilst these actions have been taking place, one of the revolving loopers has passed the previously formed loop over the second loop, and clear of the extremity of the fixed horn. This completes the operation, which then begins anew. This description shows the action of one side of the machine, and whilst it has been in operation the corresponding side, identical in construction and action, makes a corresponding series of movements in alternating order, and between the two the warp is chained in the most simple and perfect manner, and with the greatest expedition and ease.

The warp when chained is carried over pulleys, laid in

a box, and when complete tied up in a bundle and despatched for the next process. Alternately it may be allowed to fall upon the floor or into any suitable receptacle, or again, it may be passed over carrier rollers or pulleys to any convenient place.

The chaining machine makes its warp directly from the creel of bobbins ; or it will chain a warp from a warping mill, or any machine by which warps are usually made. The link it makes is drawn out with the greatest ease, and the least friction upon the threads, whilst all through the processes of bleaching or dyeing the latter are kept well in their parallel order.

The original machine, as described above, has been modified, and the illustration represents it as constructed for making two chained warps at the same time. The alteration consists of the addition of a second linker, which is of great advantage when it is required to make chains containing only a small number of ends; as when two chains are made together, the liability of the ends to break when starting the beaming frame, is considerably reduced by the distribution of the strain over a greater number of threads. Also by making two chains at once the cost is reduced. When making only one chain the second linker is disconnected.

CHAPTER IX.

YARN BLEACHING AND DYEING.

Yarn bleaching and dyeing.—The processes of bleaching.—The injector kier, *illustrated*.—Chloring.—Souring.—Improved bleaching machine, *illustrated*.—Hank dyeing by hand in tubs and vats.—Mechanical systems of dyeing.—The Klauder-Weldon machine, *illustrated*.—Its advantages.—Hank drying; disadvantages of stoves.—Improved drying machine, *illustrated*; its advantages.—Hank stretching and brushing machine, *illustrated*.—Warp dyeing.—Cop dyeing; Graemiger's machine; Crippin's machine, *illustrated* and described.—Practical recipes for dyeing, and where to obtain them.

THE operations of yarn bleaching and dyeing are sometimes conducted upon the manufacturing premises, especially when, as is most frequently the case in foreign countries, the various industries have not become highly centralized and subdivided as in the English manufacturing districts. In the latter it is often regarded as preferable to send the yarn out to be bleached or dyed in establishments where it is done on an extensive scale and where, consequently, it can be performed with greater economy and often in a better manner. For the benefit of the former establishments and of students we may briefly describe the processes of bleaching and dyeing in their chemical and mechanical aspects. Yarns are usually submitted to these processes in the form of hanks or ball warps. Many efforts have, however, been made to bleach and dye them in the cop form, as by doing so the cost of two processes, reeling and re-winding, would be avoided. Recent efforts in this direction have been attended with a fair degree of success, as will be gathered from these pages a little further on.

The process of bleaching cotton yarns consists of several distinct operations, having for their object the discharge of

the vegetable wax, natural colouring matter, dirt, and grease in the raw material, the two former being always present and the two latter liable to be added in the passages through the stages of manufacture.

The actual process of bleaching varies, as might be expected, at different establishments, and also according to the requirements of the subsequent processes through which the bleached yarns have to pass. Thus, if they are intended to be dyed with common colours, or in dark shades of browns, greens, blues, or in black, the following operations will give a fair white such as will yield satisfactory results :

1st. Boiling in soda ash, or caustic soda, which forms soap by combination with the oily matters, making them soluble, and enabling them to be washed away.

2nd. Washing, with clear water.

3rd. Treating with a solution of bleaching powder (chloride of lime).

4th. Souring, otherwise acidifying.

5th. Washing, as before.

If a more perfect bleach be desired, such as would be suitable for fine colours, say alizarine pinks and roses, then the operations become more numerous and require more care. They are as follows :

1st. Boiling in alkali as before.
2nd. Washing.
3rd. Souring.
4th. Washing.
5th. A second alkali boil.
6th. Washing.
7th. Treating with bleaching powder.
8th. Washing.
9th. Souring.
10th. Washing.

Possibly in some cases it may be desirable to repeat the last four operations to get the best effects.

These various bleaching operations are performed in the following manner :

1st. The alkali boils are conducted in upright boilers or kiers as they are called, the tops of which are made loose so that they can be lifted off for filling or discharging. These tops require to be so constructed and arranged that they can be securely fastened and the kier be made steam-tight. One of these is illustrated in fig. 167. Through the centre of the kier there passes a steam pipe terminating in a spray diffuser. The alkali liquor is forced through this pipe by steam. The bottom of the kier is usually kept covered with a layer of stones. These kiers are used in the following manner :—They are first carefully charged with yarn laid in even layers ; the top is put on and made tight and secure ; by means of a steam injector the alkaline liquor is forced up the puffer pipe or central tube previously mentioned, from which it falls upon the yarn and draining through to the bottom is again blown up the pipe, and thus kept in circulation for three or four hours. The steam is then turned off, the liquor drained away, and clean water run in to wash the yarn before it is removed from the kier. The quantity of alkali required to be used in this operation varies ; if soda ash be employed, from two to three per cent. of the weight of the yarn ; if caustic soda be used, from one and a half to two per cent. After being taken out of the kier the yarn is wrung either by hand or a hank-wringing machine to press out of it all surplus liquor. Should it be necessary to wash it again, this is effected by hanging the yarn on sticks in a large rectangular tank, through which a current of water is kept flowing, the yarn being turned over from time to time. From this washing the yarns are wrung, when they are ready for the chloring or chemicking bath as it is called.

The chloring or treatment with a solution of bleaching powder is effected in either stone or wooden rectangular tanks, the former being to be preferred. The bleaching liquor is

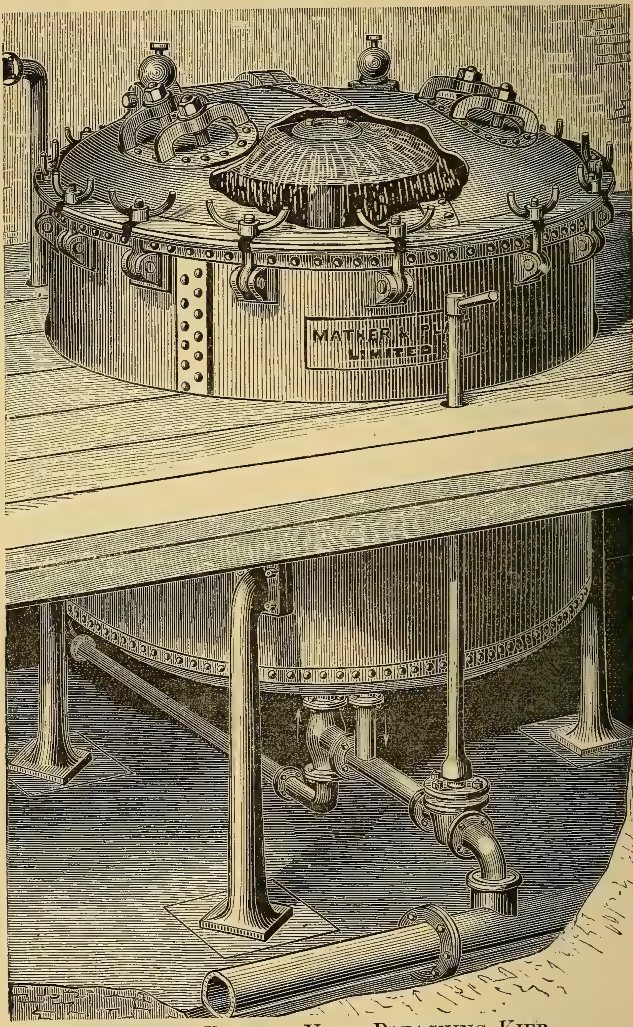


FIG. 167.—UPRIGHT YARN BLEACHING KIER.

used of a strength of 1 to $1\frac{1}{2}°$ Twaddel. The hanks of yarn are hung in this liquor from wooden sticks laid upon the sides of the tank, or sometimes the yarn is immersed in the liquor. The former method, however, is preferable. The yarn is simply placed in it until it is completely saturated, which only takes a few minutes. The surplus liquor is then wrung out and the yarns laid in heaps on wooden stillages for some hours, care being taken that no part becomes dry. This may be secured by covering them over with wet cloths.

The souring, which is for the purpose of liberating the chlorine from the chloride of lime, is carried out in the same way as the bleaching or chemicking as it is sometimes called. For this a solution of hydrochloric acid of 1° Twaddel is used; or otherwise a solution of sulphuric acid of $\frac{1}{2}°$ Twaddel. In this the yarn is immersed for about ten minutes, after which it is thoroughly washed. This final washing must be thoroughly well done, so that every trace of the chlorine or acid may be cleared away. The yarns may then be wrung out and dried for store if they are to be used in the white. If for dyeing, they only require wringing out, when they will be quite ready for the first operation.

In fig. 168 is shown a machine made by Messrs. Mather and Platt, of Manchester, in which all the operations of boiling, chemicking, and souring can be done without removing the hanks of yarn from the machine. This is a considerable advantage, as it saves labour in handling and tangling of the yarn. As will be seen, it consists of a wooden tank furnished with a false bottom, on which the yarn is placed. On the floor beside the tank are three cisterns for the reception of the liquors with which the yarn is to be treated. Centrifugal pumps, with the necessary pipes, connect the tank and the cisterns, and a steam injector is provided for spraying the goods with the alkali liquor. The yarn to be bleached is placed in the tank, and the pump, connected with the alkali cistern and the steam

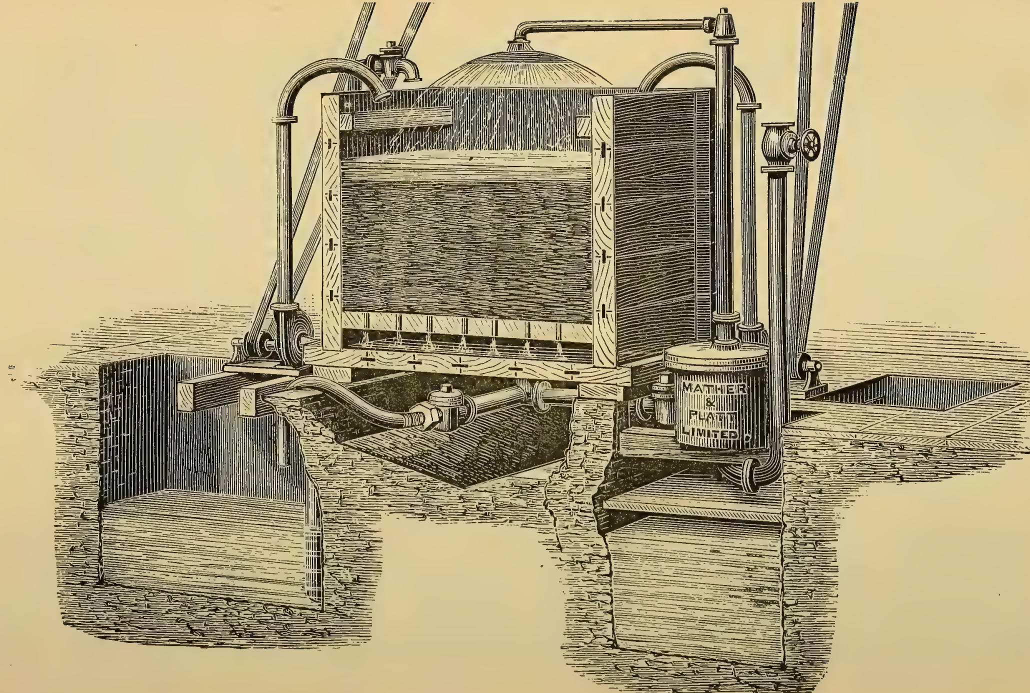


FIG. 168.—IMPROVED YARN BLEACHING KIER.

injector is set in motion. This draws the liquor from the cistern, which is conveyed through the tubes and sprayed over the yarn in the tank. The liquor drains through the yarn and runs back into the cistern whence it was first drawn. This circuitous movement is continued until the treatment is regarded as sufficient. Then the yarn is washed with water. The first pump is then stopped, and the second pump connected with the chemic cistern is set to work, and the liquor sprayed over the goods in like manner. When this has gone on a sufficient length of time it is discontinued, and the yarn is next treated with a weak acid liquor, sent over it from another pump from the acid cistern. The yarn is then well washed with clean water, and this completed, it is ready for drying. This machine is a very economical one, as it saves a good deal of handling.

A few remarks may here be appropriately introduced on the subject and process of dyeing cotton yarn. This is generally dyed in hank or warp state, the first named being the form in which it is mostly so treated. In either state it may be dyed by hand or machine. The mechanical method of treatment is, however, coming strongly to the front, as larger quantities can be treated, less labour is required, and a smaller quantity of dye-stuff is used, so that mechanical dyeing has been demonstrated to be the most economical method.

In hank dyeing by hand, when the yarn is in small lots, bath tubs are used of such a depth that they will receive the full length of the hank when hanging straight down from the stick from which it is suspended. These sticks, which are placed horizontally across the tubs, are usually made of hickory or ash, with as smooth a surface as can be got upon them. The sticks are supported by the edges of the tub.

When larger quantities of yarn are being treated, large rectangular vats or troughs are substituted for the tubs. These are of such a width that the sticks of yarn can be supported by the sides, the depth being sufficient, as

before, to receive the length of the hank. The dye liquor in the vat is heated by means of a steam pipe passing along the bottom.

The method of working is the same with both tub and vat. A bundle of yarn in hanks is placed upon a stick and carefully shaken in order to loosen it as much as possible, so that the dye liquor will perfectly and evenly penetrate it all alike. It is then dipped into the dye liquor which has been previously poured into the tub or vat. After one or two dips, the yarn is lifted and turned on the stick, so that the portion that was in the first instance upon the stick now hangs down to the bottom, the bottom portion having been brought to the top. The yarn is then again dipped, and allowed to hang in the liquor. Every bundle of yarn in the lot which is to be dyed passes through this operation. Next the first stickful is taken and the yarn turned over, re-dipped, and hung in the dye liquor. The second and the following sticks are dealt with in the same manner until all have made the passage once more. This is then repeated until the proper shade has been gained. It is next taken out, wrung free from surplus dye liquor, well washed and dried. It will be apparent from these observations that all the movements of the yarn in these cases are effected by hand.

In the mechanical system of dyeing nearly all are performed by the machine. Of these there are a number. One of the best and of the most recent introduction is the Klauder-Weldon machine, several illustrations of which are given herewith, from which the construction and mode of working will readily be gathered when aided by a brief description.

The illustrations given of the machine obviate the necessity of any lengthened description, as they will speak powerfully to the eye of the practical man in commendation of its simplicity and merits. As will be seen from fig. 169, the machine consists of a wood framework or casing, the bottom part of which forms the beck or trough to con-

tain the wash or dye liquor. Two discs properly mounted constitute a reel or skeleton cylinder, which is arranged horizontally in the frame, and is completed by the sticks carrying the yarn or slubbing which, when in position, form the periphery. The whole is covered in as shewn, and when at work the doors are closed. Fig. 170 shews the machine charged with hanks and ready for work.

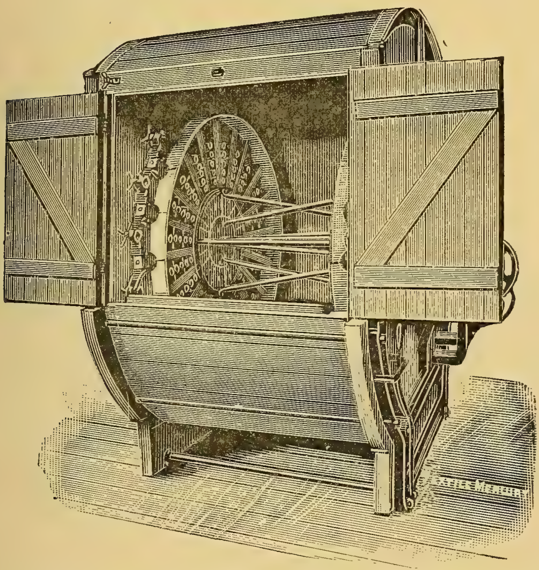


FIG. 169.—THE KLAUDER-WELDON DYEING MACHINE.

Fig. 171 shews the driving-gear, the cylinder axis projects to the outside of the casing, where it carries a worm-wheel, gearing into a worm. It is driven through suitable connections from the pulley as exhibited. If required it may be driven from a pair of step cones by which variations in speed may be had if desired. In this illus-

tration the cover is removed, the machine is shown charged with yarn, with the hanks sustained in position by one end being carried upon the stick as seen, and the second upon another stick which finds its position near the axis. In fig. 172 is given a view on the side opposite to the gearing with the pan from which the vat is fed.

The yarn is placed upon the sticks just in the manner

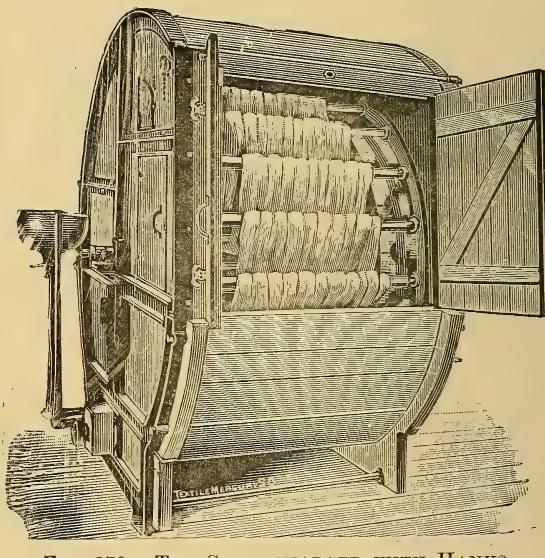


FIG. 170.—THE SAME CHARGED WITH HANKS.

it would be if turned by hand, and it is turned by an automatic trip which rings a bell if from any cause a skein or skeins should fail to revolve. In the event of such an interruption occurring, it requires but a moment to find the cause and correct it. A second set of sticks is furnished with each machine, so that whilst one lot is being dyed, another can be placed upon the second set to be ready for placing into the machine as soon as the first has been taken

out. This prevents the machine standing idle whilst the yarn is being got ready. It can thus be kept almost continually in operation, which is a great advantage. The machine can be rapidly charged and discharged, as 100 lb. can be put in or taken out in the short space of three minutes.

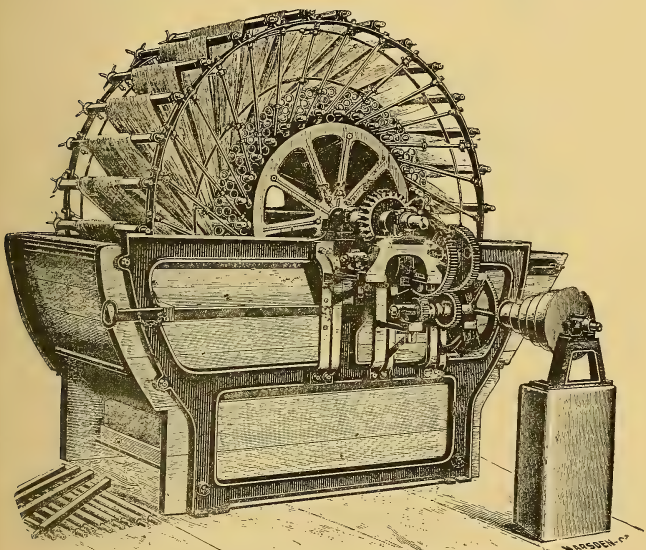


FIG. 171.—SHEWING GEARING-END AND COVER REMOVED.

In the larger machines the quantity can be increased to 300 lb., the time for dyeing being no longer.

The vat is charged with dye liquor from the pan on the left-hand side of the machine, figs. 170, 172, in which the dye-stuff is dissolved, and from which it passes into the vat whilst the machine is in operation. There is no need to withdraw the yarn from the vat whilst the fresh dye liquor is being added, as is the case in the skein-dyeing machines

generally in use. The revolution of the yarn cylinder quickly and thoroughly diffuses the added liquor throughout the vat, immediately making it all of uniform strength. When the machine has been charged, and sufficient dye-stuff has been added to match the shade required, no further attention is needed until the dyeing is finished

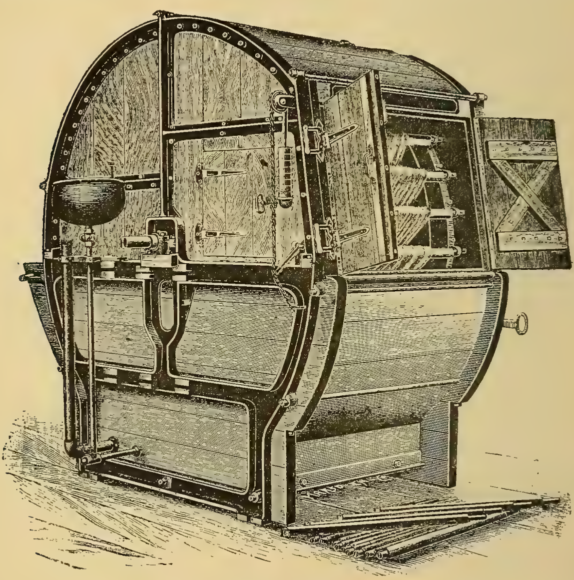


FIG. 172.—SHEWING FEED-PAN.

and the yarn is ready to be removed. Here, too, a gain of time results from the power of adding the dye-stuff without stopping the machine.

Having loaded the machines, the attendant can perform other work, and his boy assistant can attend to from two to four machines, having nothing to do after helping to load and unload until it is time to "take a matching off"

for the dyer to compare with his pattern. This is done as quickly as by the open vat process. It is part of the boy's duty also to attend to the alarm bell, but this may not be heard more than once in a week. The boy in attending to these machines does the work of many men on the old systems, and the gain from the saving of labour alone in one year will more than recompense the outlay upon the machine. Even in dyeing small lots the labour of the boy displaces that of two men.

In dyeing by open vats it is well known that the temperature cannot be raised above 204 degs. without the yarn being steam-blown and tangled, but in this machine, by its being enclosed as shown, it can be carried up to 212 degs. in the dye-bath, which obviously constitutes a very important gain. The additional heat accelerates the dyeing so much that as much work can be accomplished in five minutes as in the usual way can be done in fifteen minutes. The heat ordinarily wasted is thus much more perfectly utilized, and a large saving of fuel is effected, while the atmosphere of the dye-house is kept almost entirely free from steam. This fact alone is a great advantage, as it adds so much to the health and comfort of the workpeople.

Estimated on an average of the colours most in use, one machine will mete out and dye in ten hours 1,000 lb. of cotton yarn; it will dye 1,200 lb. to 1,500 lb. of worsted yarn; and of carpet yarn 2,000 lb. to 3,000 lb. Owing to the several points favourable to economy we have already described, there is a considerable saving of dye-wares, often to the extent of 25 per cent.

In economy of labour, in the saving of dye-stuffs, in the higher utilization of steam, in the greater production and the improved quality of work realized by the use of this machine, it will be obvious that dyers must realize a great advantage by its early adoption.

There are several other machines, known by the names of Boron, Corron, and Craven. These differ in both prin-

ciple and details, but there is no call for a description of them here.

In the various processes of bleaching, dyeing, or sizeing yarns in the hank, it will be evident that drying becomes a necessity. But as quickness is always economical, it will be equally clear that to wait for the natural drying of wet yarns in the damp atmosphere of the English manufacturing districts, would involve a long delay and great uncertainty as to when it would be completed. This soon led to the drying of yarns in stoves heated to high temperatures. But the subjection of vegetable matter, such as the cotton of which the yarn is composed, the colours with which it is impregnated, or the starch and other materials with which it may be sized, is highly objectionable, as discoloration of the fibre is likely to take place, dispersion of the colouring matters to occur, or the baking of the starch, from all of which deleterious effects upon the yarns result. It becomes preferable, therefore, having in view the attainment of the best results, to dry the yarn whenever required by atmospheric means at a moderate temperature, and in as dry an atmosphere as can be obtained. A temperature of from 70° to 100° would do no harm, whilst from 100° to 200° might do much in tendering and discolouring the yarn, or baking the starch upon it. Care of course must be taken to get quit of the atmosphere in a drying room when it has become highly charged with the moisture liberated from the yarn, and this because its power of further absorption becomes correspondingly less. If the circulation of the air through the drying room is not satisfactory, it ought to be forced by the use of propeller fans.

In order to attain the advantages of quick drying free from the disadvantages of the ordinary method, a hank drying machine has been invented, which is illustrated in fig. 173. As will be seen, it consists of a cylinder almost like that of a reeling machine, in which, however, the yarn, instead of being arranged upon its periphery, has

one end of the hank passed around an external bar, and the other over a rod arranged to fit in a position near its axis. These bars and rods are loose, and the machine is furnished with two sets, so that one can be in process of loading, whilst the contents of the other are drying in the machine, thereby avoiding loss of time. The driving is at about 110 to 120 revolutions per minute. Under

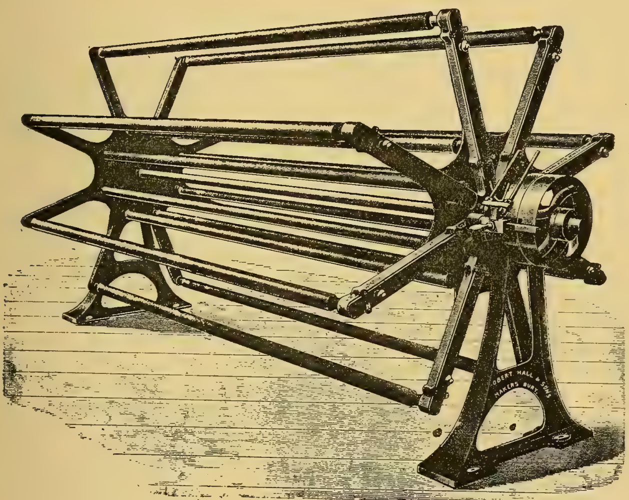


FIG. 173.—HANK DRYING MACHINE.

average conditions, one of these machines will dry from 400 lb. to 450 lb. per day of ten hours.

As this machine was first made, it was found that the portions of the hanks in contact with the bars and rods were not dried as soon as the others which were exposed to the free action of the air. To remedy this the makers have recently introduced an improvement, whereby the hank can be automatically traversed around the bars and

rods, so as to bring the protected portions under proper exposure, giving a uniform drying throughout.

By this method of drying the important qualities of softness, elasticity, colour, and finish of the yarn are preserved; there is a considerable saving of fuel and a diminished risk of fire; the dispersion of colours from one set of yarns and their absorption by others in the same room upon which they are not wanted is prevented, the yarns therefore preserving a brighter and fresher appearance through the absence of neutralization. Its use also results in a great saving of space. It is constructed to receive various sizes of hanks.

In yarn dyeing the dyeing of each colour is of necessity done separately, and the subsequent sizing process must be conducted similarly in order to prevent the running of the colours into one another, as they would do were they to be sized together. Hence the necessity has arisen for hank-dyeing, hank-wringing, and hank-sizeing machines, all of which are different from one another. Many colouring matters are of a very harsh character, and cause the threads to adhere considerably to each other, as, for instance, buff colours and others that could be named. The dipping of the hanks into the liquid bath also causes the threads to spread themselves, and when they are lifted out to overlap one another to a considerable extent. This necessitates a shaking or disentangling process, and where the threads adhere, brushing has to be resorted to in order to prepare the hank for the winding process. The stretching and brushing has, hitherto, mainly been done by men, at considerable cost in wages. To obviate this the machine illustrated herewith, fig. 174, has been invented. It is a combined hank-shaking, stretching, and brushing machine. It consists of two rollers, which are composed of copper, to prevent oxidation from contact with wet yarn. These, as will be seen, are arranged horizontally, one above the other. The top one revolves, and is positively driven. The lower one is free to turn upon its axis, and

is so mounted that in working it can be and is raised from its lowest position several inches by the revolution of a cam. When it has attained the top of this movement, it is permitted to fall without check or impediment, and this fall, which is arrested by the hanks suspended upon the top roller, shakes the latter, and re-arranges the threads in a more perfectly parallel order. There are

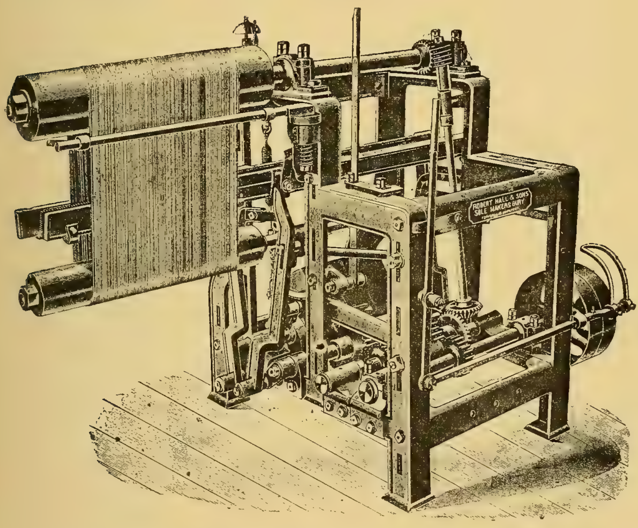


FIG. 174.—HANK SHAKING AND BRUSHING MACHINE.

also two flat reciprocating brushes, one passing through the hank, and the other outside. On the fall of the bottom roller, and while the yarn is held in a tense state, these brushes close upon it, and then move vertically downward, thus brushing the yarn upon both sides of the hank. All this time the yarn is revolving, being delivered from the positively-driven top roller to the bottom one. Of course the rate of movement of the brushes exceeds

that of the yarn, or no brushing operation would result. The yarn whilst undergoing this treatment spreads out upon the rollers, and would run off at one end, but this tendency, which simply proves the efficiency of the action of the machine, is controlled by a guard, shown near the top roller. This has two projections upon it, between which the yarn is confined. The machine is furnished with an indicator, which rings the bell when the hank has completed the one or more revolutions that may be necessary for sufficient brushing. When this has been given, the bottom roller is raised by a lever, the yarn guard drawn back, and the hanks removed. The machine is then again supplied with hanks, and the work resumed.

This machine has been specially designed to meet the requirements of the coloured branch of the cotton trade, and such others as proceed on similar lines, in which the yarn is chiefly dealt with in the hank form. Its purposes are for stretching and disentangling the yarn and for laying down the fibres upon its surface, all these being required to enable it to be worked with facility in the next process, that of re-winding. It is used with hank-sizeing and hank-drying machines, and is very effectual for its purpose, as with it a boy can easily do the work of two experienced men who work on the hand system.

Cotton yarns are sometimes dyed in the condition of warps. This is done in a dyeing machine consisting of a series of three or six vats. Between each two vats are a pair of squeezing rollers. Guide rollers are introduced into each vat, the object of which is to cause the warp to pass up and down several times in the vat, thus securing repeated immersion and thorough saturation. The vats are filled with the dye liquor, and the warps passed between the guide rollers into the first vat; emerging from these they go between the squeezing rollers which press out the surplus liquor. This is repeated until every vat has been passed through, each passage being equivalent to a dip.

If one passage through the machine does not produce the desired effect, the operation is repeated.

Usually indigo is the chief colour dyed upon warps, as it is more tractable in warp dyeing than any other colour. Sometimes the warp is simply laid down in the indigo vat, allowed to steep a short time, then it is drawn out through a pair of squeezing rollers and over a winch. This is placed at some distance above the vat so that the indigo has time to become oxydized before the warp reaches it.

There is yet another form in which yarn is dyed, and that is the cop form as it comes from the mule. There has long been a strong desire to accomplish this in a satisfactory manner, but for a long time very little success attended the efforts made to solve the problem. Of late years, however, some considerable progress has been made, and it would appear that complete success is almost within sight if not already attained.

The advantages of dyeing yarns in the cop would be considerable. It would save the cost of the reeling process altogether, and it would diminish waste. The difficulties, however, seemed almost insuperable. Simple immersion of cops in a dye liquor, however prolonged, is not sufficient; for whether the saturation commences from the exterior surface or the interior by means of the spindle holes, or whether it is conducted by both of these ways at the same time, the dye liquor has to filter through the successive layers, and consequently as it approaches either surface it has become weakened and has less colour to impart to the last layer than it gave to the first. This is the case in whichever direction the process of saturation is conducted. It is also the same when operating in the two directions at once. Besides this the time required is very great. This, however, would not matter much if the result was satisfactory, which as the process has been usually conducted has not been the case. It has never been possible to get anything like a uniform shade of colour. The mechanical construction of the cop has pre-

vented this, the result having been that the exterior layers have been dyed of a full shade while the central portion has been quite white, grading from that through all the intermediate tints to the full colour of the outside layers.

During the past two years, however, two cop dyeing machines have been constructed which have attained marked measures of success. The first of these is of Swiss origin, the inventor being named Graemiger. The second is a Lancashire invention, that of Mr. Crippin, a Manchester manufacturer.

Graemiger's invention consists of a hollow drum which is fixed in a dye vat so that the lower half is immersed in the dye liquor. Internally this drum is divided by partitions into four segmental chambers, the two lower ones being connected with a centrifugal pump. One of the upper chambers is connected with an air pump. The third chamber is open. The ends of the drum are perforated. Against each side, and arranged to be in very close contact, are two discs which are also divided into segments corresponding to those of the drum and perforated in a similar manner with holes which correspond exactly in position with those in the sides of the drum. The cops are placed on perforated tubes of special construction, the ends of which fit exactly and tightly into the holes in the discs.

The action of the machine is this: the vat is fitted with dye liquor, heated by steam pipes if necessary, the pump is set in operation and draws the dye liquor through the holes in the drum which it returns to the dye vat. The top left-hand segment of the discs is filled with cops previously placed on the skewers. The drum is given a quarter of a revolution which immerses the cops in the dye liquor. The suction of the pump draws the latter through the cops. The next segment of the discs is charged, carried, and saturated in a similar manner, and the third is treated likewise. This brings the segment first immersed out of the dye liquor and into contact with

the right-hand segment of the upper half of the drum. The air pump in connection therewith draws air through the cops and exhausts the superfluous liquor. The process is then finished, the cops being usually sufficiently dyed. The revolution of the machine is partially automatic. Every lot of yarn put into the machine goes through this cycle of operations.

The cop dyeing machine of Mr. Crippin is constructed on different lines though embodying its leading principle, saturation of the cops by atmospheric exhaustion. This machine, illustrated in fig. 175, consists essentially of three parts: 1st, a dye vat or tank for the reception of the dye liquor, heated if required by steam pipes; 2nd, a dyeing chamber placed at one end of the dye vat with which it communicates; 3rd, exhaustion or receiving cylinders placed at the opposite side of the tank. The dyeing chamber is cylindrical in form, and is open at the bottom to the dye vat whilst at the top it communicates with the exhausting vessel mentioned.

In charging it the cops are placed on perforated skewers of a special construction. From 150 to 200 are skewered and fixed on a circular perforated plate termed the cop plate, which is placed in the cop chamber and is so constructed that when in position it divides the chamber into two portions. When the cover of the chamber is put on it presses tightly on a projection on the central part of the cop plate and keeps it firmly in position. By means of a steam injector a vacuum is formed in the exhausters, and by suitable connections this is communicated to the cop chambers, and by means of this the dye liquor is drawn from the dye vat through the cops and into the exhausters or receiving vessels. When a certain quantity of the dye liquor has been drawn through the cops, which is indicated by gauge glasses, a vacuum is created on the opposite side and the flow of the dye liquor is reversed, it being drawn from the cop chamber to the vat.

These operations are repeated four or five times when the

cops are found to be thoroughly dyed. Air is then drawn through them which forces out all the surplus dye liquor, the cop plate is removed from the chamber and the cops dried, which finishes the operation.

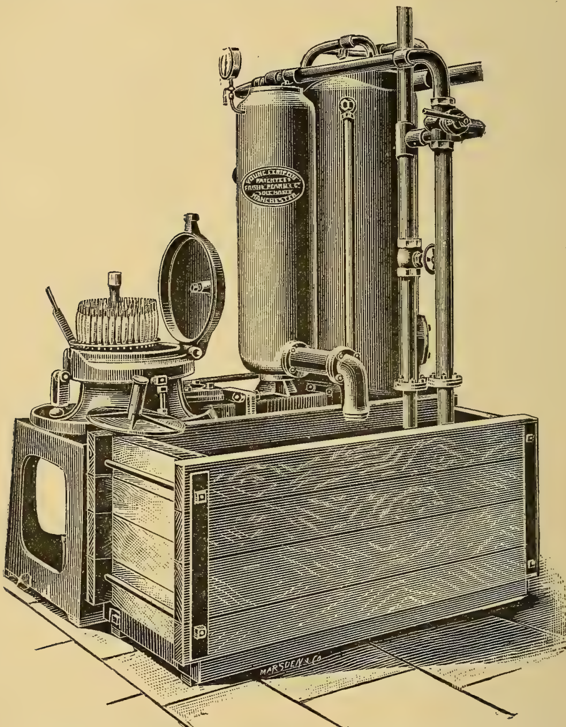


FIG. 175.—CRIPPIN'S IMPROVED COP DYEING MACHINE.

This machine works in an exceedingly efficient manner, and gives perfectly uniform shades in each cop and throughout all the cops of a batch, and all successive batches when the usual care is taken to keep up the strength of the

liquor; and this uniformity of shade throughout successive batches is a matter of considerable importance. It can be used very successfully in the dyeing of the direct cotton colours, such as benzo-purpurine, or the Titan colours. It may also be used in the dyeing of diazotizable colours, such as diamine blacks or browns, and also with basic colours, such as magenta and auramine, while with a certain modification in its construction it gives excellent results with indigo.

Cop dyeing is very rapidly effected with Mr. Crippin's machine. Five minutes is usually sufficient for dyeing a simple colour like benzo-purpurine, or Titan yellow; and twenty-five minutes will suffice for producing a diazotized diamine black. A basic colour like auramine takes ten to twelve minutes. Hitherto good results have not been attained with mordant colours like alizarine, but by the use of the Erban Specht process, or some modification of it, more success might result.

There are other cop dyeing machines, but they have not been a commercial success, and call for no further notice here. Those who are interested beyond satisfaction with what is given here may refer to a valuable paper upon cop dyeing by Dr. C. O. Weber, which appeared in the "Journal of the Society of Chemical Industry" in 1892.

It would be out of place in this essay to burden its pages with recipes for dyeing, but the author may be permitted to direct the attention of those interested in this department to the columns of the "Textile Mercury," in which the earliest and the most abundant information is given relating to new dyes, processes, and their practical application and values as judged from a workshop and commercial standpoint. This journal is issued weekly by Messrs. Marsden & Co., Manchester.

CHAPTER X.

The Development of the Art of Dressing or Sizeing, and the Machinery Employed in the Processes.

Sizeing: its meaning and purpose.—Early Indian sizeing.—The sizeing of Dacca muslins.—Indian size.—Early English size; a recipe.—Recent progress in size compounding.—The mechanical appliances of sizeing.—Hand warp dressing and drying.—Duncan's suggestions of improvements.—Hand warp sizeing.—Sizeing shops.—Warp-dressing in the power-loom.—Radcliffe's suggestions for improvements.—Johnson's invention of the dressing machine.—Detailed description, with improvements, *illustrated.*—Further improvements by other inventors.—Hornby and Kenworthy's tape-sizeing machine.—Kenworthy, the inventor.—His tape-sizeing described and *illustrated.*—Its distinctive merits.—James Bullough, the inventor.—Stimulation to invention.—Bullough, Walmsley, and Whittaker's invention of the "Slasher" sizeing machine, an improvement upon the tape-sizeing machine.—Improvements of the Slasher by Atherton, Kinlock, and Swainson, and William Garnett.—Leigh's "silica" size; results of experiments with it.—The Slasher sizeing machine of to-day; description and illustration.—The creel.—The size trough.—The boiling pipe.—The immersion, sizeing, and pressure rollers.—Importance of keeping the rollers in order.—The passage of the yarn.—The drying cylinders.—The headstock: the fan, the opening rods, the measuring roller, and the marker.—Ball warp and hank sizeing.—The hand hank-sizeing machine, *illustrated.*—The power hank-sizeing machine, *illustrated.*—Size for coloured yarns.—The systems of sizeing in use, and the causes of their maintenance.—Ball warp sizeing.—Dressing.—Slashing.—Hank sizeing in parti-coloured goods.—Cotton manufacturing, spinning, and weaving; the operatives.

IN the advanced stage of the art of cotton manufacturing, as it exists at the present time, sizeing is correctly regarded as the most important process of the series included in the second division of the trade which is the subject of this treatise. The nature of cotton yarn, which is composed of short filaments of vegetable down, loosely com-

pacted into a thread by spinning or "twisting," as it is sometimes called, renders some sort of dressing, or "sizeing," the meaning of which will be best understood if we take starching as its equivalent, necessary before it can be woven into cloth with any facility or satisfaction. In passing we may observe that cotton is not a "fibre," though commonly spoken of as such; this conception is a popular error. It is a vegetable seed down. Sizieng is the application to the yarn of a starchy or glutinous composition, which passing between the loosely compacted filaments causes them to adhere firmly together, and thus the better to resist the strain and friction incident to the weaving operation. The strain arises in the formation of the shed for the passage of the shuttle, as explained at an earlier stage; and the friction in the passage of the warp over the carrier beam, under and over the lease rods, and through the healds and the reed. The severe action to which the yarn is exposed in the rubbing of the threads against one another, against the healds in shedding, by the friction of the reed in its movements to and fro, and by the passages of the shuttle through the shed, renders this protection absolutely necessary. Were single cotton yarns to be used without sizeing, they would soon fray and break, or ends of filaments or fibres, as we may call them for convenience, and which stand up above the common surface of the yarn, would break off, and gathering together would form "beads," or "runners," as weavers term them, behind the reed, which gradually getting larger would break down the warp threads. The process of sizeing lays these projecting extremities of the filaments upon the body of the thread, rendering it smoother, stronger, and much better fitted for its purpose than before.

There can be no doubt but that the earliest Indian weavers of cotton would experience these difficulties, and it is equally certain that there must have been a very early resort to a simple system of sizeing before much

useful result could have been derived from the attempt to weave it. Testimony to this effect is found in the Institutes of Menu, No. 397. "Let a weaver," says Menu, "who has received ten palas of cotton thread give them back increased to *eleven by the rice water*, and the like used in weaving, &c."

In the manufacture of the celebrated muslins of Dacca, a great deal of care was taken and labour made of this process. The yarn was steeped in water three days, the water being changed twice a day; then rinsed, reeled, dried, and then reeled off into skeins. These were again steeped in water, withdrawn, wrung between two sticks, and exposed to dry in the sun. The next stage was to untwist them and immerse them in water mixed with fine charcoal powder, lampblack, or soot scraped from the sides of an earthenware cooking vessel, in which they were left for two days. Being withdrawn they were rinsed in clear water and hung up in the shade to dry. These skeins were again reeled, and again steeped in water for one night, removed and spread out over a flat board and rubbed over with a size or paste made of coie paddy, or rice from which the husk has been removed by heated sand, and a small quantity of fine lime mixed with water. Such, very briefly stated, was the method of sizeing followed in Dacca as we are informed in "An Account of the Cotton Manufactures of Dacca in Bengal," by an English gentleman who resided there in the first half of the present century. It would be interesting did space allow to comment upon some of the particulars given by this writer, but the indulgence cannot be permitted.

In the ordinary processes of manufacturing in India it is hardly likely that such an elaborate method as that roughly sketched above would be followed. It is known, however, that rice has formed the basis of the size used in India from the remotest times, as the extract from Menu given previously sufficiently proves. As a rule it was what in an English home would be simply called

starch. In the manufacture of the muslins as described above, the subjection of the rice in the husking process to a treatment with hot sand might very probably transform the starch it contained into an impure dextrine, or British gum as it is now commonly called.

Elaborate and careful tests have been made of the percentages of size contained in cotton goods of the native Indian manufacture. Cotton Loongees were found to contain from 2·75 to 15·3 per cent.; cotton Sarees from 6·54 to 13·4 per cent.; muslins from 3·8 to 23·78 per cent., the remarkable fact in this instance being that the finer qualities contained the largest amount.

As previously shown, the English weaver of cotton began with and, for more than half a century, only used cotton yarn for weft, his warp being of flax. This required sizeing almost as much as cotton, consequently when he began to make his warps from Arkwright's water twist he was not quite a novice in sizeing. The materials most commonly used were wheat flour and potatoes boiled to the required consistency in water, and without the addition of the other materials now commonly employed. As the modern sizer well knows these would lay the loose fibres, consolidate the yarn, and give a certain amount of smoothness, but in the dry terms of the year, such as during hard frosts, dry winds, or hot weather, they would too readily part with their moisture to the atmosphere, leaving the warp harsh, dry, and difficult to weave. In the latter half of the last century the conditions of living were very different to what they are now; the fresh foods that are now procurable all the year round were not then to be had, and in some districts salted fish, and in others bacon and salted beef formed important staples of diet. In the preparation of these brine was extensively used. Some genius connected with the art of weaving was struck with the idea that the warp might be "cured" or rendered softer and easier to weave if a portion of fish, or beef brine, was added to the size. This was done with benefit, and its

use continued far into the present century. When these sources of supply began to fail a curious substitute was adopted: this was human urine, which was collected at the mills and works, and often from the public urinals in the streets in receptacles for the purpose. This was done up to as recently as 1850-60. It was then discovered that there was nothing essential in these liquids beyond the salt they contained, and as a consequence common salt began to be added to the flour and potato starch generally used, a corresponding disuse of urine following.

A considerable time previous to the above date, however, a good deal of crude experimentation amongst weavers and others interested was going on. Warp sizeing had become a separate business to a great extent, and every sizer made a different compound for the purpose which he kept as secret as he could from all competitors. The efforts made were chiefly directed to increasing and maintaining the softness of the warp during all conditions of weather and atmospheric changes. That these gradually led to a measure of success will be apparent from the following recipe of a size extensively used by good sizers in both England and Scotland in the years 1840-50.

"Take 1 lb. of Soft Soap,
2 ,, Tallow,
2 ,, Soda.

Mix them well with as much boiling water as will reduce the mixture to the consistence of cream—then take seventy or eighty gallons of water, milk-warm, put in it about 240 lb. of good flour, and then add the mixture, taking care to stir all well together; and in three or four days the size will be fit for use. It is then to be reduced as the work may require it on being put into the tub."

From this it will be evident they were on the right track, but as yet a long distance from the goal. The lubricants, as the first three articles were termed, were

used in various other proportions by different sizers; to keep the cloth a good colour some substituted white soap for the soft.

We need not trace in minute detail the progress of the art of sizeing and the composition of size, as a brief summary will now suffice for the remainder of the review of the subject. The great progress that has been made during the past thirty-five years had its origin in the American Civil War. The cotton famine in Lancashire, induced by that event, completely disorganized the cotton manufacture, and the commerce in its products. The great trade with the Eastern world was conducted upon the basis of conformity to certain particulars. The staple articles had to be of given dimensions, contain specified numbers of threads of warp and weft in the inch of cloth, and to be of certain weights, or they were practically unsaleable. To the minds of Eastern consumers these weights formed almost a guarantee that the fabric contained a certain amount of cotton, and the piece of cloth under ordinary conditions could always be bought within a given range of prices. As cotton became scarce and rapidly advanced in value, compliance with these requirements became impossible, and disorganization of the trade quickly followed. Attempts were therefore made to make up the weight by the addition of extra size, which up to a certain extent was successful. But the limit of this effort was soon attained in the then state of knowledge of the subject. The inferior quality of the cotton that came into use, and the imperfect yarn it produced, would not carry a heavy weight of size, breaking down under the burden. Then again the size was badly compounded, and in the process of weaving a great percentage was rubbed off and wasted. Kaolin or China clay was the chief material introduced in addition to the previous ingredients, and being perfectly neutral from a chemical point of view, and divisible into the most minute state, it proved an excellent article for the purpose. The difficulty

was to keep it in the yarn, and this problem was not solved for some time.

We may now briefly glance at the mechanical appliances of sizeing in their course of development in this country. The earliest system of sizeing or dressing of the warp was that of the hand-loom weaver, who dressed his warp in the loom. Having prepared his size in the manner indicated previously, he rubbed a portion upon a brush about 18 inches long and about 3 inches wide, the brush being composed of the best black bristles. Taking a second brush of like dimensions, he worked the two together until the size placed upon them was evenly distributed. He then proceeded to the back of his loom, and began to brush the extended length of warp backwards from the lease rods to the beam, thus laying the loose ends of the filaments of the cotton upon the yarn in the manner best suited to its passage through the healds and reed afterwards. When this was finished the warp length just sized was wet, and could not be woven until dried. To effect this with more expedition the weaver introduced a wing-shaped fan, which he waved backwards and forwards over the damp warp. Still in wet or damp weather the atmosphere had little power of absorbing moisture, so another method of effecting the object was resorted to. This was the "drying-iron," a long iron bar with a flattened end, which would reach across the warp. The flat part was made red hot, and moved over the top of the warp, as near to it as could be got without touching it. Many a warp has been burnt across by the carelessness of the operator in letting it drop upon the yarn, when it would instantly go through, and sometimes falling upon the loose down beneath, set the contents of the loom in flames. It ought to have been moved about close under the warp, and it would have dried it more quickly and have avoided this risk. After the drying had been safely performed, the dressed length was again brushed, in order to separate any threads adhering together,

and a small quantity of melted tallow was brushed over it. As this process recurred at frequent intervals, it will be evident that further improvement was needed.

Such was the general process of warp dressing or sizeing at the beginning of the present century. John Duncan, who gives these particulars in his "Essays on Weaving," published in 1808 in a collected form, suggests that the process should be separated from that of weaving entirely, and whole warps sized at once, in order that the weaver might work continuously at his weaving. These suggestions appear to have borne fruit at an early or later time afterwards, for the hand-loom weaver began to size his own warp all at once by a domestic process, and in the mills containing power-looms dressing and sizeing machines were introduced. The domestic process, as carried on in the home of the hand-loom weaver, was, briefly told, as follows: A wooden trough, about 4 feet long, 14 inches wide at the top, 8 inches at the bottom, and 8 inches deep, was constructed. A pair of small rollers were inserted in each end of this trough, about half way of the depth. The warp was passed between these along the length of the trough through the next pair, and out at the end, sometimes through a bell-mouthed tube. As soon as the warp end had thus been passed through, the trough was filled with boiling size of the consistency of cream. Immediately the length in the trough was saturated, the weaver and his assistants would begin to draw the warp through, coiling it on a sheet behind them. To preserve their arms and hands from the scalding size, they put stockings on the former, and held thick cloths in the latter. When the warp was drawn through, it was extended upon the drying frame, made of two standards, joined by cross-pieces and having a number of horizontal pegs, extending from the front and back. The warp having been passed from one standard to another until it was all upon the frame, was thus exposed in the garden, lane, or village street to dry.

When the weather was unfavourable, it was dried indoors before a good fire. This system lasted as long, or nearly so, as the handicraft form of the industry. Towards the close, however, "putters-out," as employers were termed, began to relieve the weaver of this duty by sending the warps to be sized before they gave them out.

Parallel with this development sizeing became a business of itself, the sizers seeking their customers amongst the "putters-out," and small mills which had not set up plant of their own. The places where this business was conducted became known as sizeing shops.

Though the power-loom had been made a capable machine at the close of the last century, it could make no headway owing to the necessity of dressing the warp in the loom. Every loom required a weaver, and what with tending his loom and dressing his warp, he could make no more cloth—about 15 yards of, say, 60 picks per inch per day—than the hand-weaver. The over-production of yarn and serious depression in the spinning and weaving trade in 1799, compelled attention to this subject, and Mr. William Radcliffe, a manufacturer of Mellor, Derbyshire, about a dozen miles from Manchester, after struggling ineffectually to get an export duty placed upon English yarns, saw the promise of a remedy in increasing the efficiency of the loom. In his employ he had an ingenious weaver with very strong inventive capabilities, named Thomas Johnson. He called Johnson to his aid, and expressed a wish that he should set to work and invent some method of sizeing the entire warp before it was put into the loom. He had not long to wait for his reward. He succeeded in inventing the dressing machine, and on February 28th, 1803, he took out a patent for it, No. 2684. This was an invention which deservedly ranks very high in the annals of the cotton trade. The first part consisted of a beaming-frame, such as was described in its most perfect form in the preceding chapter; the second was the dressing machine proper, and which in its

principles and general outlines was the same as the more perfect machine he patented on June 7th, 1804, No. 2771, and which, with subsequent improvements, became the well-known dressing machine that served the trade so efficiently until superseded by the tape-sizeing and slashing-sizeing machines. As the machine which made Cartwright's power-loom a commercial success it may be described in detail, which is rendered easy by the fact that an excellent illustration of it is given in White's "Treatise on Weaving," published 1846, which we reproduce.

It should be premised that the handloom weaver's idea of warp-dressing was a process that should lay down upon the surface of the thread the ends of the filaments of the cotton that the spinning process had failed to control, and so prevent them gathering in the shed and forming runners upon the yarn, and ultimately obstructing the weaving so much as to prevent its being proceeded with. His idea, therefore, was to encase the yarn in a coating of starchy matter, which should fulfil the requirement mentioned. The succeeding theory, and the one which is now in vogue, is to saturate the yarn in such a manner that every filament shall be bound to its fellows, so as to constitute the whole a solid thread. The former served the purpose of the time in which it was in vogue; the latter more perfectly meets the needs of the present day. The essence of Johnson's invention was to perform this dressing of the yarn, literally putting a coat upon it, by a machine in the manner the hand-loom weaver had done it by hand; substituting, in fact, a mechanical for a manual process.

Johnson, in his first patent, endeavoured to do this by the use of circular revolving brushes, but it was soon found that the result was not nearly so good as that obtained from the hand process. The circular brushes were therefore abandoned, and a system of parallel brushing invented by him, in which the brushes were traversed in one direction in contact with the yarn, and withdrawn from it when being carried back to the point from which

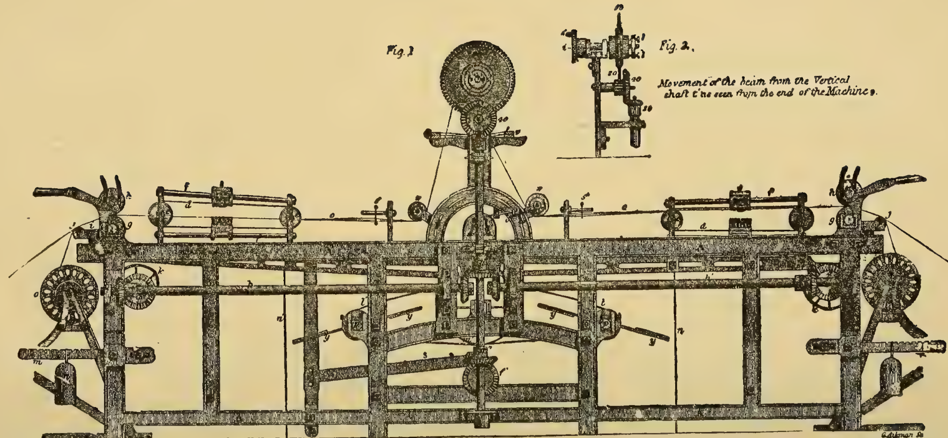


FIG. 176.—JOHNSON'S WARP-DRESSING MACHINE, IMPROVED.

a new stroke had to be made. This he accomplished by means of a crank-motion now familiar in the mechanical trades, and from which the machine ultimately got the name of the crank dressing-machine.

The illustration, fig. 176, and its description, will make Johnson's invention clear. It must first be observed that the machine is practically a double one, each part working to deliver its product to a common centre. The working parts are attached to or carried upon the oblong frame A. The oscillating brush-frame is marked *a*, sub-fig. 1, and extends the length of the machine, its pivot being in the centre. There are a pair of brushes at each end, *b b*, the upper one arranged to brush the top surface of the warp, and the lower to do the same for the under one. In their traverse the brushes operate upon the yarn when moving towards the ends of the frame. As the brushing was required to be in one direction, on their return to their first position, they were raised or lowered out of contact by the oscillatory movement of the frame in which they were carried, this being produced by the eccentrics *k*, which were set in opposition, so that whilst one elevated the end of the brush-frame as high as it was capable of doing, the opposite one permitted it to be correspondingly depressed. As will be seen from the same fig. when the brush frame end is elevated, the upper of its two brushes is carried out of action, and is making its return traverse to its working position. At the same time the lower brush is in action brushing the underside of the warp *c*. The left of the fig. shows the frame down and the upper brush at work, being the reverse of that on the right. As will be observed, the machine has a creel at each end, generally made to contain six beams, only one of which, *o*, is shewn on account of space. The unsized yarn, *c*, was drawn from these beams, and passing over a small carrier roller, was conducted between the two rollers, *g h*. These are the dressing-rollers. The lower one was half immersed in the dressing composition or size, and in its revolutions

carried enough of this to apply to the warp in its passage. The upper roller, which was driven by friction from the lower roller *g*, was a compression roller pressing the size into the warp, and squeezing out the surplus. The fact that the yarn was not immersed in the size at all is distinctive of the system of dressing as compared with the more modern one of sizeing, and, as will have been gathered already from previous explanations, proves its inferiority, and demonstrates the certainty that it would be superseded by the present system as soon as the merits of the latter came to be understood. The warp on leaving the dressing-rollers immediately came under the action of the brushes, the operation of which has been sufficiently explained, except that it remains to be mentioned that they were traversed backward and forward by the band *d*, to which they were attached, and which passed around the pulleys *e*, the latter being suitably actuated for the requirement. The yarn leaving the brushes passed beneath the conductor rollers *w*, which are also measuring rollers fitted with appropriate indicators giving the length. Leaving the measuring roller, the yarn passed upwards through the lease healds laid horizontally a little below the beam. The beam was placed at this height in order to get space in which to complete the drying of the yarn before it passed upon it. This was effected by means of two fans, one for each end, and steam-pipes.

As illustrated and described here the dressing machine contains numerous improvements in details added by succeeding inventors. As Johnson left it, there was no compression roller over the dressing roller, and the size was very crudely and unequally applied, and the yarn adhered very much together through unequal drying. Johnson made it to pass through a reed which improved it, but chafed it considerably, undoing the work of the brushes, whilst it was liable to fill up with pasty size gathered from the yarn in its passage. The difficulties were so great and apparently so insurmountable, that Johnson

advised his patron to abandon the attempt to make it a full success. Other inventors assisted in the task of its improvement, notably, Archibald Buchanan, of Catrine Works, Scotland, who in order to keep the threads from adhering, introduced a copper plate, perforated with holes, for the reception and perfect isolation of each thread, instead of the reed, which effected a great improvement. With further improvements in details and skill on the part of operatives, fairly good results were attained, and the use of the dressing machine divided the work to be done with the system of ball-warp sizeing that sprang out of the domestic system of the hand-loom weaver. It will, however, be obvious that though a very meritorious invention at the time of its birth, the dressing machine was very defective for its purpose. As first invented, the mass of warp threads was too dense for the brushes to penetrate, and they did the work very imperfectly. To remedy this it was divided into two portions, six beams being put at each end of the new machine, and their threads run together upon the loom beam, as shown in our illustration. This necessitated the duplication of every part of the machine making it, as we have termed it, a double one. But even then its work was imperfect and its production small, and totally inadequate to keep pace with the growing requirements of the trade. No wonder, therefore, that attempts soon began to be made towards a further advance.

The next most important of these was the tape-sizeing machine. This was a Blackburn invention, emanating from Brookhouse Mills, which was patented in the names of William Henry Hornby and William Kenworthy. The first named was the proprietor and the second his manager, and subsequently his partner. Undoubtedly the latter was the principal inventor, both in this and subsequent inventions in which their names were associated. This machine marks the transition from the idea and principle of dressing entertained by the hand-loom weaver and by

Thomas Johnson, to the more perfect idea of "sizeing" or starching by thorough saturation, which has ever since governed the process. We believe Kenworthy was a native of Denton, near Stockport, from which place he migrated to Preston and thence to Blackburn. He would thus probably have acquired some knowledge of the condition of the art of sizing in the district where Johnson's inventions were in use. Becoming associated with Messrs. Hornby and Birley, of Brookhouse Mills, who were spinners, manufacturers, and ball-warp sizers, he would find full scope for his knowledge and inventive powers. These were subsequently exercised to considerable purpose.

The first important invention with which Kenworthy's name was associated was the tape-sizeing machine called the tape machine, from the peculiar mode of distributing or laying out of the warp threads, so as to get them dressed or sized in parallel strips or bands, the equivalents of the "beers" or "half-beers," which have been previously explained. This was accomplished by passing them through a comb-bar in those quantities in which state they somewhat resembled tapes of yarn. There was no particular merit in this arrangement of the yarn, but rather otherwise. It was, however, a distinct departure from, and an improvement upon, passing the entire of the warp in one strand through the size, as was done in ball-warping sizeing. It facilitated saturation of the threads much more perfectly than the dressing machine. The three accompanying illustrations over the general fig. No. 177 and under the sub-figs. 1, 2, 3, 4, 5, 6, fully explain this important invention. Sub-fig. 1 is a plan, 2 a side view, and 3 a longitudinal section; 4, 5, 6 shew details. Unquestionably the inventor was indebted for some suggestions to both Johnson's dressing machine and the ball-warp sizeing plant as it then existed, as several points from both are incorporated therein.

The machine, it will be seen, consists of the oblong frame A, which as usual forms the support for the work-

ing parts. The beams, A, contain the yarn to be sized, and are placed in the creel of the machine. From them the yarn is led to the sizeing troughs, of which there are two arranged one behind the other and marked—first passing through a ravel or comb *b*, in fig. 3, and shown detached in fig. 4; figs. 5 and 6 show two other forms of the same thing. Next going over a small carrier roller, the yarn descends into the sizeing trough or box carried down by the rollers *e g*, *e′ g′*, the direction of its movement being shown by the arrows. The rollers, *g g′*, press out the superfluous size from the yarn as it leaves them. The drying is effected by the two tin cylinders, which are steam heated. In order to get a longer stretch and more time in which to dry the yarn, it is conducted, as it leaves the size, first to the more distant cylinder, returning over it, and then passing around the nearest, which it leaves to be conducted over the carrier-rollers, *m*, *n*, *o*, to the yarn beam P in the front.

The tension upon the yarn is regulated by the pressure between the two receiving and delivering rollers, *e g*, *e′ g′*, in the sizeing-box, through their connexion with the lever 11. The racks 14, carrying the pivots of the upper rollers, can be adjusted from the winch-handle through the small pinions, 13. The weighted lever, 2, is for regulating the pressure upon the delivery-rollers.

Perhaps the most novel feature in the machine was its sizeing the yarn in bands or tapes like "beers" and "half-beers," and passing it upon the beam in this manner like the old ball-warp was passed upon the weaver's beam from the beaming machine. This was mistakenly thought to be its most important merit, and therefore it was termed the tape-sizeing machine from it. Its greatest merit, however, really was in its being a sizeing machine, and immersing the yarn completely in the size. It was erroneously thought that the formation of the yarn into these bands or tapes strengthened the threads by causing them to adhere slightly together during their passage over the space

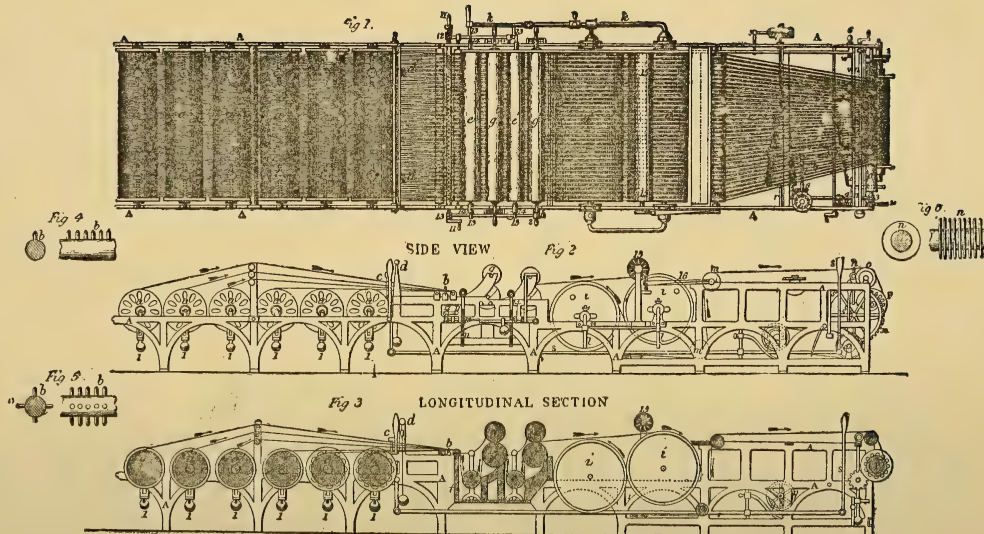


FIG. 177.—VIEWS OF ORIGINAL TAPE-SIZEING MACHINE.

between the warp-carrier beam in the loom and the healds, their next resting place. This, however, was not so, as when the threads arrived at the lease rods and were separated, and shedding commenced, the strain upon them was at its maximum, and the weakest places were then found out and broken as each individual thread was separately tested.

The comb or ravel *b*, previously pointed out as effecting this division into tapes, was caused to vibrate or oscillate freely as the warp passed over it. The roller, *o*, was the measuring roller, its axle being furnished with a worm, which through the bevels, 5, 6, drove the shaft, 7, which again carried the worm, 8, this being the marker which touched the yarn with colour to indicate the piece lengths. The shaft *r* was the main shaft, which was furnished with the usual fast and loose pulleys, *s* being the starting handle.

One of the most excellent features of this machine, and which, with perhaps the exception of a short interval, has been retained ever since, was its possession of a variable driving arrangement, consisting of two cone-drums to regulate the winding action of the receiving beam, according to its varying diameter. The action of these we need not stop to explain, as to-day they are sufficiently well known. The shaft, *v*, carrying the driven cone, was furnished with a pinion, *w*, which drove a train of three spur-wheels, *x*, *y*, *z*, by which rotary motion was imparted to the beam. As the warp, now properly sized and dried, approached the beam from the roller, *m*, it passed through the ravel, *n*, which was generally used as a condenser to bring its breadth within the width between the flanges of the beam, *c*. For a while at first the arbor of the beam was sometimes made hollow, the hole being square, in order that if required it could be slipped off like a bobbin from a spindle. This was done in order to facilitate the placing of two beams together on a common arbor in one loom when it was desired to make a wide cloth. They

were thus joined without any trouble, and in working were paced together.

In the plain cloth trade, that is, in all sections in which plain warps of the natural colour are used, the machine just described has been the basis of all subsequent improvements. No attempt having the shadow of a chance of success has been made to supersede it. All efforts that have proved of commercial value have been to improve it by simplifying or perfecting its details. The first important advance made upon it was that of the late James Bullough, founder of the great machine making firm of Howard and Bullough, Accrington. Mr. Bullough was for a considerable number of years an overlooker in the establishment of Messrs. Hornby and Kenworthy, Brookhouse Mills, Blackburn. Mr. Kenworthy was the managing partner in that establishment, and in his early experiments, it is stated, availed himself to a considerable extent of the inventive skill of Bullough, whom he called in to assist him. Mr. Kenworthy also encouraged him to work out the details of his own inventions, for some of which he became celebrated, and from them derived the means that ultimately formed the foundation of the Accrington machine making establishment already mentioned.

The decades of the present century from 1830 to 1880, during which the transformation of the cotton trade from a manual to a mechanical industry was taking place, offered promises of great rewards to successful inventors, and the greatest in the first thirty years, when there was most to be accomplished. Hence in every centre of the industry large numbers sprang up, though most of them were failures. But the records of their efforts are preserved in the Patent Office, and there the inquiring student will find the wrecks of thousands of mechanical absurdities. Judging from the traditions that have survived, if any reliance may be placed upon them, which should not be much, there was a great deal of unscrupulous cribbing of ideas from one another, then quick races to the Patent

Office in order to be first. Thus it often happens that the inquirer into the development of the mechanical side of industry is baffled in his desires to allocate the credit for an invention to the right person.

James Bullough was one amongst a group of these men, and in the improvement of the sizeing-machine to which we are referring, he had as joint patentees with him two men named John Walmsley and David Whittaker. Justice demands that the names of these men should be mentioned. Bullough, however, having already achieved a reputation as an inventor, his name naturally enough became the predominant one in association with the invention of the Slashing, or Slasher Sizeing Machine, as the improved form came to be called. The patent for this was numbered 2,293, and was granted, October 7th, 1853. The improvement effected was practically a very simple one, but it had important effects in greatly increasing the production of the machine. In Kenworthy's machine, as we have just seen, the yarn was conveyed from the large yarn beams through a reed, healds, and ravel, which were only introduced to comply with the supposed requirements of the sizeing process, as shown in the dressing machine. Bullough discarded these, sending the yarn forward and down into the sizeing trough in a perfectly even sheet as it came from the beams. This greatly accelerated the work of "setting in," avoiding the loss of time common to the older machine. In order to preserve the lease it was necessary, in commencing the sizeing of a new set of beams, that the yarn of each beam should be twisted to the ends of the finished one, precisely as a new warp is now twisted to a set of healds. This could only be done in the machine. The loss of time will be obvious. The same patent includes improvements in the warping mill in which it was endeavoured to take the lease at that stage, and also mark the cut lengths. These, however, were soon after abandoned, and a method adopted of getting a bastard lease by striking a comb into the sheet of the extended warp.

This was sufficiently good for the purpose, satisfying all requirements of the case.

Since Bullough's invention this type of sizeing machine has not been attempted to be superseded with any prospect of success for cotton work; it has, however, been considerably improved in details by various succeeding inventors. A bare enumeration of a few of these must suffice.

In September, 1854, three joint inventors named Atherton, Kinlock, and Swainson, we believe of Preston, relieved the great strain upon the yarn by inventing a method of positively driving the steam cylinders and the squeezing rollers instead of by the drag of the yarn. They also applied the frictional arrangement of the old dressing frame for winding the yarn upon the loom-beam. These formed very considerable improvements as the elasticity of the yarn was thus preserved until it reached the loom, where it was needed in the action of shedding.

Within a week or two of the above patent being granted another was taken out by William Garnett, presumably of Low Moor, near Clitheroe, for the improved way of taking the lease by "striking" a half reed or comb into the warp, as previously mentioned.

Atherton and Kinlock, early in November, carried their previous improvements a little further. In the new arrangements the squeezing rollers, rotatory brushes, and the traction rollers in front of the cylinders, were actuated by gearing, "so as to take off all strain from the yarn." Several other details were also improved.

Nothing further occurred that can be called noteworthy in connection with this subject until April, 1856, when John Leigh of Manchester patented what became known as "Silica-size." This was one of the most daring inventions ever attempted in connection with this subject, and as the experiment, so far as weaving with it, came under the writer's personal notice nearly throughout its course, a few words may be devoted to the subject. The invention consisted in the substitution of silicate of

soda, or silicate of potash, for the sizeing compounds then in use. These were to be used either alone or in combination with sulphate of barytes and the various starches. They were mostly tried alone. Almost two years were spent in experimentation. In 1858 room and power was hired in Jubilee Mill, Blackburn, and an effort was made to place the invention upon the market. Fifty looms were bought, and placed in the charge of Mr. Edward Whittlo, the first secretary of the Blackburn Power-loom Weavers' Association, who had just vacated that post. Great difficulty was encountered with the new size, as the yarn after it had gone through the size was found to have a most destructive effect upon the drying cylinders, which being composed of tinned plates had the tin stripped from them in a very short time and were rendered useless. It was attempted to overcome this by the substitution of one or more steam chests for the drying cylinders of the sizeing machine, so that the yarn might not come in contact with metallic surfaces. This was patented by Thomas Leigh, the brother of John. But the difficulties were not overcome. The yarn was got through the sizeing process, and passed to the loom. Here it cut down the healds to such an extent that they were worn out before a piece of an $8\frac{1}{4}$ lb. Indian shirting, or what should have been such, was woven. This, of course, was inadmissible. The cloth when woven weighed pounds beyond the proper weight, and felt cold and greasy to the touch. The struggle was continued for some months, when the inventors finally failed with very heavy liabilities which had accrued during the conduct of the experiment. The highest hopes were entertained of its effecting a perfect revolution in the trade, but all were dashed together. The looms fell into Whittlo's possession, and he struggled on some time as a manufacturer in a small way.

The Slasher sizeing machine was subsequently improved in numerous further details by succeeding inventors, the chief efforts being directed to securing a uniformly even

delivery of yarn from the back beams in both length and tension, and to relieve it from all strain or stretching in its passage; to prevent the baking of patches of size upon it when the machine was stopped, and to perfectly dry it before it reached the loom beam; to mark the piece-lengths accurately, and to press the beams in order to make them hold more length and to preserve their cylindrical form. The latest piece-marker and a presser will be described further on.

The addition of the improvements just indicated have brought the sizeing machine up to its present degree of excellence, and as now made it is illustrated in fig. 178. A brief description, after the preceding sketch of its development, will suffice for all purposes, as the function of each part named will be readily understood. The portion of the frame on the left of the figure is termed the creel, and carries the series of large warping machine beams, called "back beams" from the fact that they are placed at the back of the sizeing machine as here shown. These creels are usually made to hold six or eight of these beams, generally in two tiers, whilst any less number can be worked. By the addition of a portable stand at the extreme end another beam or two could be added if needed, which will, however, hardly ever be required. The beams are generally placed in the creel to unwind in opposite directions, the yarn of the first to come off at the top and passing down under the second, which is in the lower tier; the yarn from both then comes upward and passes over the top of the third, and taking the contribution from this beam, it passes down under the fourth, bringing the yarn of that beam also with it. This goes on to the last beam of the set. The arrangement described secures a uniform delivery of yarn from each beam, which is an important matter in the subsequent process of weaving, where the tension of every thread in the warp as it comes off the beam must be as nearly as possible uniform if good work has to be made. The yarn from

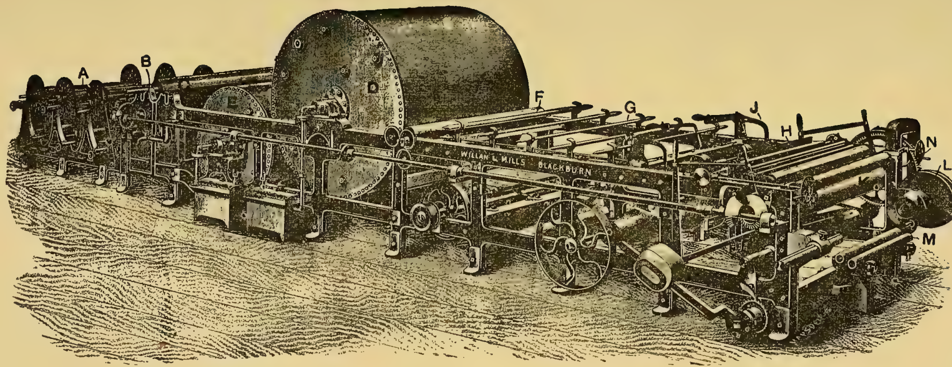


FIG. 178.—THE IMPROVED "SLASHER" SIZEING MACHINE.

each beam having been gathered together in this manner, it passes over two small tin carrier rollers in an even sheet, and descends into the size trough, B.

This trough is divided lengthwise into two unequal portions, the smallest being nearest the steam cylinders. The partition does not go to the bottom, as a space is left for the passage of the contents of the smaller one into the larger. The smaller one is a sort of reservoir for the larger one, and it receives the size direct from the beck in which it has been prepared. The object of this indirect feeding of the size to the trough in which it is applied to the warp is to prevent the raw size coming into contact with the yarn before it is properly boiled. The first stage of boiling is therefore commenced in the small trough, and as it is drawn from this into the large one at the bottom, the boiling is completed before it rises into contact with the yarn passing around the immersion roller. We have before observed that this boiling bursts the granules of the starchy matters in the size, reducing them to a much finer condition than before, and therefore making the composition all the more fit for application to the yarn. The admission of the size to the small section of the trough is automatically regulated by a ball tap, and so requires no attention, after being adjusted, to keep up the proper supply or to prevent over-filling.

Along the length of the bottom of the larger section of the trough is fixed a steam pipe, sometimes in a single length and sometimes made double by being forked. This is perforated with a large number of small holes, and is suitably connected with a larger pipe from the boiler. When the tap is opened and the steam admitted it forces its way into the size-box, and soon causes its contents to boil freely, by which the size is brought to its finest condition.

This section of the size-box contains a series of rollers. Enumerating them from the position nearest the creel they are as follows: 1st, the immersion roller; 2nd, the

first pair, called the sizeing rollers ; and 3rd, the second or pressure rollers. The immersion roller is composed of copper, and is about five in. diameter. Its function, as its name implies, is to carry the yarn down into the size. By means of a rack and pinion it can be adjusted at any depth in the trough that the work in process may require. This differs according to the counts of yarn and the number of ends contained in the warp. Coarse counts or a large number of ends in the warp require deeper and consequently longer immersion to obtain thorough saturation than fine counts and few ends.

The sizeing rollers come next. The bottom one is like the last-named, composed of copper. The top one is of iron, and is covered with two or three layers of flannel, and these with a layer or two of calico. This clothing is to form a cushion into which the yarn can imbed itself in its passage between them. These rollers are correctly termed the sizeing rollers, as their function is to press the size, which to some extent is lying upon the surface of the yarn, into its core. The yarn imbedding itself into the clothing of the top roller receives a gentle pressure upon every side, which forces the size into it, and thus fills the interstices between its filaments and perfects its saturation.

The pressure or finishing rollers are the next pair, and are constructed in like manner, and again the bottom one is of copper and the top one of iron, the latter being clothed, but not usually so thickly as the preceding one. The function of this pair is to press out of the yarn all the superfluous size it may have absorbed or be carrying on its surface. The weight of the top roller is varied sometimes by the quality of the work it has to perform. If it is required to press out of the yarn a large percentage of the size absorbed, it may be temporarily weighted for the occasion. When light, it will press out a less quantity of size and the warp will be the heavier.

The immersion roller and the two bottom rollers of the

pairs are made of copper in order to resist in a better manner the action of the acids generated by the fermentation of the size and which are always present in it. Formerly the first bottom roller was made of wood, because it was found that when of copper it absorbed so much heat from the boiling size that if the machine was compelled to stop for a short time, the size was baked upon the warp, which was thus seriously damaged at that spot. The wood roller never absorbed heat to this extent, but it had other defects, as it soon displayed signs of wear and was difficult to keep in good condition. As the defect of size-baking generally occurred in the stoppage during the doffing of a filled loom beam, to overcome it an ingenious device was invented by which the attendant was enabled to run the machine very slowly while doffing instead of making a perfect stop. This did not allow the yarn to remain upon the hot roller long enough to bake, and thus the difficulty was obviated, and the copper roller was reintroduced and is now found in all good machines.

It is important that all these rollers should be kept in good condition, as upon their proper clothing, cleanliness, even surfaces, and easy working, depends in a great degree the perfection or otherwise of the work going through the machine. The two top rollers are surface driven, the bottom ones being positively driven from the side shaft.

The yarn passes from the beams over two tin carrier rollers, and descends to a more or less depth in the boiling size under the immersion roller and up therefrom to and between the sizeing rollers, the superfluous size being pressed out and flowing back into the trough. Having passed these, it proceeds to and between the next pair, where any superfluous size that may remain is squeezed out, and the sizeing process is then completed.

The wet yarn now passes directly upon the large cylinder, D, which is heated by steam and is generally worked at a pressure of from 5 to 15 lb. per square inch according to the counts of the yarn and the number of ends

in the warp. This cylinder slowly revolves, the yarn passes over its top, around its front and under its bottom, thus almost encircling it, whence rising it is delivered to the small cylinder, E, around which it passes in like manner. The latter cylinder is steam-heated like the first. The sheet of yarn in its passage around the large cylinder has one side only in contact with its heated surface, which of course results in one side being more perfectly dried than the other. The second cylinder is therefore introduced to perfect the work, which is accomplished by delivering the damp side of the sheet of yarn directly upon it. This cylinder is of smaller dimensions because it has only about one third or one quarter of the work to perform that falls to the share of the large cylinder. The yarn on leaving the small cylinder travels a little above the floor to a small carrier roller on the same level, near the front of the large cylinder, thence ascending to and over the tin carrier roller, F. The second stage of the passage of the machine, the drying of the warp, has now been completed.

As might naturally be expected, the yarn having passed through the size and the drying process in a sheet, the threads are found adhering together. It would not do for the warp to go to the loom in this condition, therefore they must be separated. This is effected by the series of iron rods, G. In commencing a set of beams the sizer inserts a cord between the threads of each beam so as to separate the yarn of every beam from that of the other. These cords passing through the machine, come up over the carrier roller, F, and by their means the rods, G, are easily inserted in their proper place. The threads must now separate or break; they do not often do the latter as the adhesion is not strong enough. In order to cool the warp and perfect the drying, a fan, which is rapidly driven, is introduced beneath the warp at this point. The yarn now passes forward towards the loom beam, but before it arrives thereto it is measured by a roller—around which it passes and is marked at certain distances in one, two, three, or four

lengths to a piece, which indicate to the weaver the places at which to insert "headings," "middlings," or as in dhooties, cross borders, or other decorative additions as may be required. The lengths are determined by the number of revolutions of the measuring roller, which is 14·4 in. diameter. There are a number of adjuncts consisting of improvements in details beyond what have been remarked upon in this brief sketch of the sizeing machine as it is to-day. They, however, will be more properly noticed in describing the practical working of the machine hereafter.

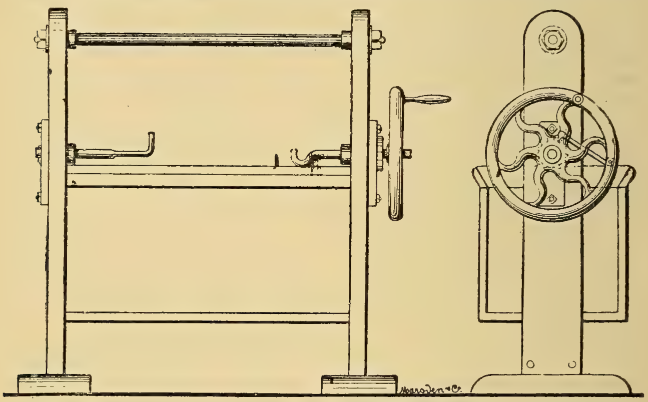


Fig. 179.—Hand-Power Hank-Sizeing Machine; Front and End View.

The next and last system calling for notice is that of hank-sizeing. This is generally adopted where warps are composed of yarns of different colours. In these cases the yarns are first dyed in the hanks, and afterwards sized in the same state. Hence there are hank-sizeing machines for working by hand or power, according to requirement. In principle there is little or no difference between them; it is mostly in magnitude and capacity of production.

The hand-power hank-sizeing machine is illustrated in fig. 179, a front and end view being shown. This

machine is used for very small quantities and for samples. The box suspended in the middle of the frame is the size trough, and in this the hanks are placed until saturated. When this has been properly effected, they are taken out and each hank placed upon the two hooks shown, twisted, and the superfluous size wrung out of them. The number of turns to which the hank is subjected determines the amount of size to be left in. More turns compress out more size, fewer turns less. The hank is then removed, and the process continued.

In the larger power machine shown in outline in fig.

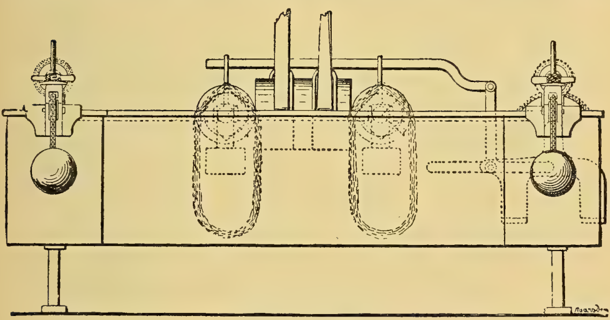


FIG. 180.—STEAM-POWER HANK-SIZEING MACHINE.

180, substantially the same process is gone through on a greater scale. As will be seen, the hanks revolve in the size. The machine is furnished with an automatic wringing and reversing motion, which can be regulated according to requirement. It is constructed with either one or two pairs of hooks. With one pair it gives a production of about 25 lb. to 30 lb. per hour; with two about double that.

Fig. 181 illustrates another type of machine, but which embodies the same principles, though the arrangement is somewhat different. In this case there are six pairs of hooks placed on circular revolving discs. It requires a

man and a boy to attend to it. The boy immerses the hanks at the end of the machine, and they are carried forward upon small poles placed on a pair of endless chains. The man places the hanks upon the pairs of hooks in succession. In the course of one revolution of the discs, these are wrung and unwrung automatically; then the hanks are taken off and the machine charged

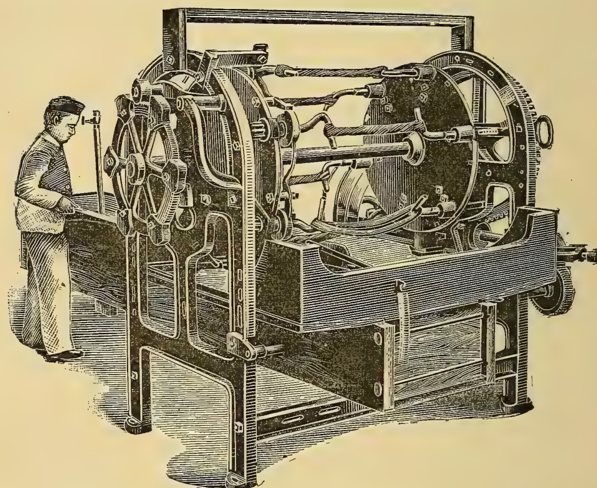


Fig. 181.—Improved Disc Hank-Sizeing and Wringing Machine.

again. This type of machine gets through a great deal of work, the production per day of ten hours being from 1,200 to 1,500 lb. It is largely used in the Lancashire districts weaving coloured goods.

The size used in these machines, and for coloured yarns generally, differs from that used for grey goods, as it is essential that the colours of dyed yarns shall not be injured by any chemical constituent of the size, or dulled by its opacity. Directions are given subsequently.

When the hanks have been wrung out of the size they are placed upon horizontal poles to dry, or where the yarn drying machine described in the last chapter is in use, they are passed thereto and dried upon it. Running at about 100 to 120 revolutions per minute, and with the room in which it is placed heated to a temperature of about 100° F., the production of dried yarn, 20s to 36s, from the machine will be 400 to 450 lb. per day of ten hours.

After drying the hanks are taken and brushed either by hand or by the machine already described (fig. 174) in the previous chapter. The production of brushed yarn from this machine, with a lad attending it, will be about 1,000 lb. per day of ten hours.

The various systems of sizeing and their development have now been passed under review, and the student will, we trust, have been able to gather therefrom the reasons which called them into existence, their functions, and their respective merits, and the requirements which have led to their maintenance or induced their supercession. In one form or another, however, they nearly all survive to a limited extent as specialties, and at these a glance may for a moment be cast.

The old system of ball warp sizeing is now very little used in the plain or grey cloth trade. It maintains its ground, however, in the manufacture of coloured goods where the whole warps are dyed in one colour, and in the manufacture of cords, moles, and other kinds of heavy fustians. In the districts where these are produced, it is still conducted as a separate business on account of the bulk and costliness of the plant, and the requirement for its economical working.

As just indicated, the old system of dressing is still in use for the fabrics stated, but this is only to a very limited extent.

The Slasher system of sizeing is in use for all the lighter classes of self-coloured fabrics, usually termed grey goods,

with the few exceptions previously named where dressing is retained.

Hank-sizeing prevails in the coloured goods trade in nearly all cases where coloured yarns are mixed.

This brings to a close our exposition of the invention, progressive development, and functions of the chief mechanical appliances used in the series of processes compendiously, but erroneously grouped under the name of "cotton manufacturing," terms which properly include the spinning division as well. The trade in its entirety should be called "the cotton manufacture," and its two principal divisions "cotton spinning" and "cotton weaving;" these, of course, having their subdivisions. The persons following the first pursuit as employers should be called "cotton spinners;" those in the second "cotton weavers," not manufacturers. The operatives engaged in them should be respectively "operative spinners" and "operative weavers," and those of the subdivisions should bear the names of the sections in which they are engaged.

The reader who has followed our exposition up to this point will have few difficulties in the practical part that follows, as he will at once comprehend the reason why and the purpose of everything that is done, and will be ready at once to pronounce whether it is in accord with, or contradiction of, the basic principles of the particular process in which it appears.

The reader will observe that throughout this chapter we have spelt the word "sizeing" with the vowel e in the middle, which is not the common method to-day. It is, however, we believe, strictly correct and according to the best analogies of the language. During the last century and the early part of this, the word "sizing" meant to assort yarns from hand spinners into sizes so as to get some approach to uniformity. This ceased with the improvement of spinning machinery.

CHAPTER XI.

THE CONSTRUCTION AND EQUIPMENT OF A WEAVING ESTABLISHMENT.

Cotton "manufacturing," its trade and technical signification.—Proportionate capital employed to wages paid.—Selection of locality and site of premises.—Causes of concentration in towns.—Essentials of success.—Requisite conditions and circumstances.—A humid location best.—Traffic and industrial conveniences.—Materials of construction for buildings.—The weaving process should be upon ground floor.—Arrangement of light.—Plan of weaving establishment, *illustrated.*—Location of the machinery.—Rope-driving *versus* wheel-gearing.—Supplementary engine.—Steam generating arrangements.—The Lancashire boiler with Galloway tubes, *illustrated.*—Increased economy desirable.—Tentative improvements, *illustrated.*—Mechanical stokers.—Mechanical stoker feeder, *illustrated.*—Economizer, *illustrated.*—Improved boiler valves, *illustrated.*—The steam engine, *illustrated.*—Gearing, shafting, and pulleys, *illustrated.*—Swivelling bearings, *illustrated.*—Toothed gearing, belts, and ropes.—The introduction of rope-driving into Lancashire.—Best material for driving ropes.—The strain and flexure of driving ropes.—The Lambeth rope, *illustrated.*—Its peculiarity of construction, tensile strength, flexibility, and inelasticity.

COTTON "manufacturing," in its trade and technical signification, is the second great division of the cotton trade, as "spinning" is the first. It commences to handle the material at the point left off in the latter. For various economical reasons, as partly explained in the preceding chapters, it is to a large extent conducted as a separate business from spinning. This, however, can only be done with advantage where the two branches are highly developed, and closely concentrated side by side, as in the English manufacturing districts. But the modern spinning mill is not so dependent upon the proximity of the weaving mill as the latter is upon the spinning mill,

because a spinning establishment may be usefully and profitably employed in the production of yarns for the export trade, which as a rule are destined for consumption in countries where the primitive industry of hand-loom weaving still maintains a lingering existence. Thus it is that in foreign countries, such as those of the continent, Canada, the United States, and the various States of South America, the two divisions of the trade are more often found conjoined than apart. In Bombay this remark partially holds good, though there, notwithstanding the spinning industry was founded to supply the hand weavers of the country, the tendency to separate has not only become manifest in the cases where the two were associated, but has made some progress. Should the cotton trade in the future in any of the other countries just named attain large dimensions, and become concentrated, there can be no reasonable doubt but that the same causes will operate there as here, and produce the same results—its separation into two divisions. In this treatise the subject is considered from the point of manufacturing having a separate and partly independent existence.

In proportion to the amount of capital invested a weaving establishment employs a far larger number of workpeople, and pays a proportionately larger sum in wages than one engaged in spinning. This renders skill and tact in dealing with workpeople of much more importance than in the first division, as there is a correspondingly greater liability of misunderstandings and ruinous disputes arising, which should, if possible, without the sacrifice of vital interests, be avoided.

The selection of a locality and site demand the greatest care. Free and unobstructed access to a good supply of the best class of operatives is one of the primary elements of success, as without it the production from the plant will be less than it ought to be, and consequently will be burdened with a heavier proportion of the fixed expenses of the establishment than will be that which comes from

competing mills obtaining a higher average production. In the second place, the quality of the production will be inferior, and will therefore sell for less money; this will lay the foundation of an inferior trading reputation which it will be difficult at any time, and under any circumstances, afterwards to shake off. A good trade name should in all cases be sought, as it is always a source of profit; in good times yielding its owner better prices for his wares, and in slack times obtaining for him a preference of such orders as may be in the market.

Once upon a time in the history of the trade mills for both spinning and weaving were planted in isolated villages at considerable distances from the larger centres of population, and to and from which supplies of materials and productions had to be carted at considerable expense. Compensation was obtained for this in the low rate of ground rents and wages; especially, and principally, the latter. At that time employers paid any price for labour which seemed to please them in the then circumstances of the trade. But since 1850 there has been a steady increase in the demand for labour, and a rapid development in its organization which quite precludes the possibility of the existence of such irregularities to-day as were then common. The Blackburn Standard List of Wages, for the manufacturing division of the trade, first established in 1853, has, with modifications, been extended to almost every one of the manufacturing districts, and recently by agreement between the employers and employees' representatives has been modified and adopted as a uniform list applicable throughout the largest portion of the trade. Thus deprived of the power of obtaining compensation for admitted disadvantages from a lower wages rate, few country mills have been able to maintain their ground against the competition of those in the towns, and only under very exceptional circumstances could any be successfully established and carried on to-day. Such locations should therefore be avoided, unless on the most careful and rigid

investigation they can be shown to offer permanent compensatory advantages. This result is a national disadvantage, as it strongly tends to congest the population in large towns.

The remarks made in the writer's previous work on "Cotton Spinning," in Chapter III., on the essentials of success may be transferred to this place with only a few verbal alterations, being quite as applicable to manufacturing as to spinning. It is there said: "Competition in the cotton trade is now so severe, both at home and abroad, that anyone newly adventuring therein cannot afford to neglect the slightest matter that may be conducive to success. If possible, the beginner should start with a sufficiency of capital to provide a perfectly new establishment, well found in every respect, and have a balance left large enough to conduct its commercial operations with advantage. Without a level beginning the chances of success are proportionately diminished. The locality must be well chosen, the site of the mill carefully selected, the mill well constructed, the machinery must be of the best for its particular purpose, the management must be skilful, economical, and thoroughly honest. The manager must be perfectly versed in the practical details of his business, and able to manage men as well as machines. The commercial division of the business must be conducted with skill, prudence, foresight, and a fair share of enterprise. Old methods of procedure must not be retained from an excess of conservative sentiment when it is obvious that they have been superseded by improvements; and machinery must not be retained in work, though intrinsically in good condition, when the progress of mechanical invention has virtually rendered it obsolete. Any person not willing to recognize and act upon these truisms had better not invest his means in cotton manufacturing. Technical, scientific, and commercial knowledge, combined with steady industry and prudent enterprise are required to ensure success." Read "weaving establishment" for "mill" in this quota-

tion, and it will be perfectly appropriate. Since the above words were first written, now nine or ten years ago, nothing has happened in the condition of either the spinning or weaving branches of the trade to lessen their applicability, or weaken their importance; on the contrary, everything that has occurred, and the prospective course of events in connection with the trade intensify and increase their force both to the present and probable future of both branches of the trade.

The foregoing reflections dictate that the weaving establishment under consideration should be located within the area wherein the class of goods to which it has to be devoted are usually manufactured; that it should not be isolated in a country village, unless under the exceptional conditions just described; and that it should be within an area where it will not be subject to extra charges for carriage of supplies inward or of production outward. Anything in this shape above that paid by competitors would be a tax upon the profits to which they should not be subjected. Other matters should also weigh in the selection of a site: it should afford facile and quick access to the market, in order that the persons charged with the duty of buying and selling may always be able to get there in the most prompt manner, and with the least loss of time to take advantage of momentary phases of strength or weakness that may pass over it; the former offering advantages in selling, and the latter in buying, which cannot properly be neglected. And care should be taken that there is also easy access to post-offices, telegraphs and telephones, as on many occasions such facilities induce the conclusion of business that in other circumstances might go elsewhere.

In regard to the selection of a site, it may be as well to make another quotation from "Cotton Spinning," the subject of the present remarks being the same with only a slight variation. "Having decided upon the locality the next matter is to select a suitable site, and in this

practical considerations should mainly govern the decision. Cotton has a considerable affinity for moisture, and when provided with its natural requirements in this respect its fibres are more flexible, and yield more readily, without breakage, to the treatment of the processes through which they have to pass in manufacture. This is true in spinning, but is more forcibly so in weaving, because when in the loom it has had added to it the various ingredients used in the sizeing process. The tendency of starch, kaolin, and various chemical salts with which the yarns are too often overloaded, is to build up a rigid wall of these materials around them, and so greatly reduce their flexibility. Though this is the result it is not that which is sought. Therefore it is endeavoured to be obviated by various well-known means. But sizeing under any circumstances in manufacturing is a necessity which is as old as the art itself, being required to protect the tender material from the severe friction to which it is subjected by the action of the reed; but the stiffness thus induced must be moderated as much as possible. The native Hindoo weaver carries his loom into the open air under the shade of a tree, and digs a trench over which he extends his rice-sized warp, the natural drainage into the trench, and the evaporation from which improves the weaving of the warp. The old English hand-loom weaver in the cotton trade, in order to get the advantage of a bare earth floor, preferred to place his loom on a ground floor or in a cellar to an upper room, and often dug a hole beneath his treddles, into which he poured water. The evaporation from this kept his warp in the best condition for weaving. In this procedure he unconsciously imitated his Eastern competitor with his trench in the earth. The same necessity is incumbent upon his successor the modern cotton manufacturer who desires to get the best results. If wise he will, in this country, plant his shed in a valley protected from dry winds, and open to moist ones; that is, to be more explicit, and having particular application

to the English manufacturing districts, it should be sheltered on the east and north, and open to the west and south. The subsoil should be a stiff impervious clay, affording a solid foundation for structure, and in the vicinity retaining the rainfall as it were in a subterranean reservoir, evaporation from which, in the dryest seasons, will moisten and soften the atmosphere around. Should it be necessary to store a water supply, the lodge to contain it should always be placed on the side from which the dry winds blow, mostly the east. This will help to temper the dry atmosphere to the advantage of the work in process. An abundant and never-failing supply of water is an essential requisite, and if this is not present in a stream, river, or canal, provision will have to be made for storing the necessary quantity in a reservoir; and if the supply from the latter is used for condensing purposes, arrangements will have to be made to keep its temperature low enough for such a purpose.

"Good roads giving easy access for cartage purposes, and to and from the residences of the operatives are important. The site should be within such a distance of the homes of the latter as will permit all employed to go to meals and return within the time legally provided for that purpose. Of course, there will always be some exceptions in which operatives will come from too great a distance to permit of this. Provision has then to be made for allowing food to be taken upon some part of the premises not amenable to the visits of the factory inspector, or where the law would be liable to be violated, entailing responsibility upon the owner. This state of matters always causes some extra supervision, and consequently entails cost and risk. A short walk in the open air, such as is had by going home to food is always invigorating and promotive of health amongst the operatives, and ought in all cases, where practicable, to be encouraged. It refreshes them and breaks the monotony of their labour, to which they afterwards return with renewed strength." These

remarks are transferred from "Cotton Spinning," being equally pertinent here.

As in the spinning mill the fittest material for the edifice will be decided by the circumstances of the locality. If stone lies in close proximity, and can be easily quarried, it constitutes an excellent, durable, and cheap material. When this is not the case, and the site selected contains clay from which bricks can be made, these will generally be found the most economical and suitable material. Should it be necessary to provide a reservoir for water, any clay excavated for this purpose, and also that from the foundation trenches, will be available for this use.

The section or special branch of the business of manufacturing to be followed is usually decided upon in advance of the erection and furnishing of the buildings, this being necessary to permit of the purchase of the most suitable plant for the purpose, and its construction by the machinist, that it may be ready for delivery when the establishment is ready to receive it.

In cotton manufacturing, experience has long ago demonstrated that the weaving process at least should always be conducted upon the ground floor, and never in rooms, however apparently firmly built. The vibration in the latter is always injurious, and in some cases is so to such an extent that to neutralize its effects would require the purchase of yarns a farthing per pound better in quality to produce cloth equal in quantity and quality to that which could be obtained from the use of materials a farthing per pound less on a ground floor. In the weaving process the warp yarns are subjected to considerable strain and friction, which is a severe test of their strength and quality. The vibration of the floor upon which the looms are placed when in rooms above the ground greatly increases the unavoidable strain of the shedding of the warp, and causes numerous breakages that impede and diminish production, and deteriorate the quality of the work. In these times of severe competition and low profits, under ordinary

circumstances no such disadvantage as manufacturing in rooms could safely be faced with any rational expectation of avoiding failure and bankruptcy.

Having been guided in the selection of a site by the considerations thus set forth, the plan of the building should provide that the bays of the roof of the weaving-shed should run in a direction from east to west in order to present the glazed portion of the bay to the north, the volume of light obtained from this point of the compass being the greatest, most steady, uniform in quality, and the best adapted for manufacturing purposes. This point secured, regard must be had to the arrangement of the looms which ought to run in aisles at right angles to the bays of the roof, in order that the slays or lathes of the looms shall not cast shadows upon the warp shed in the process of weaving, and thereby interfere with the weaver's quick perception of yarn breakages or flaws of other descriptions.

The plan, fig. 182, represents a well-arranged weaving shed to contain 510 plain looms, 40-inch reed space, with the necessary preparation machinery of the following proportions :—There are three winding machines placed side by side, with ample space between them for the operatives. Each machine contains 300 spindles and is arranged to wind from mule cops upon warper's bobbins ; gauge of spindles $4\frac{1}{2}$ inches. The driving pulleys are 12 inches × $2\frac{1}{2}$ inches and make 140 revolutions per minute, and with a 7-inch tin cylinder cause the spindles to run at 650 revolutions. The total length of frame is 30 feet $7\frac{1}{2}$ inches × 5 feet 6 inches wide. Each machine is driven over swing pulleys. In the same room as the winding machines there are six self-stopping beaming machines, having V creels, each to contain 504 bobbins. The machines are placed so as to deliver their full beams into one main passage and have each plenty of space allowed round the creels for bobbins, etc. The floor space of each machine, including creel, is 13 feet 9 inches × 7 feet 3 inches, with

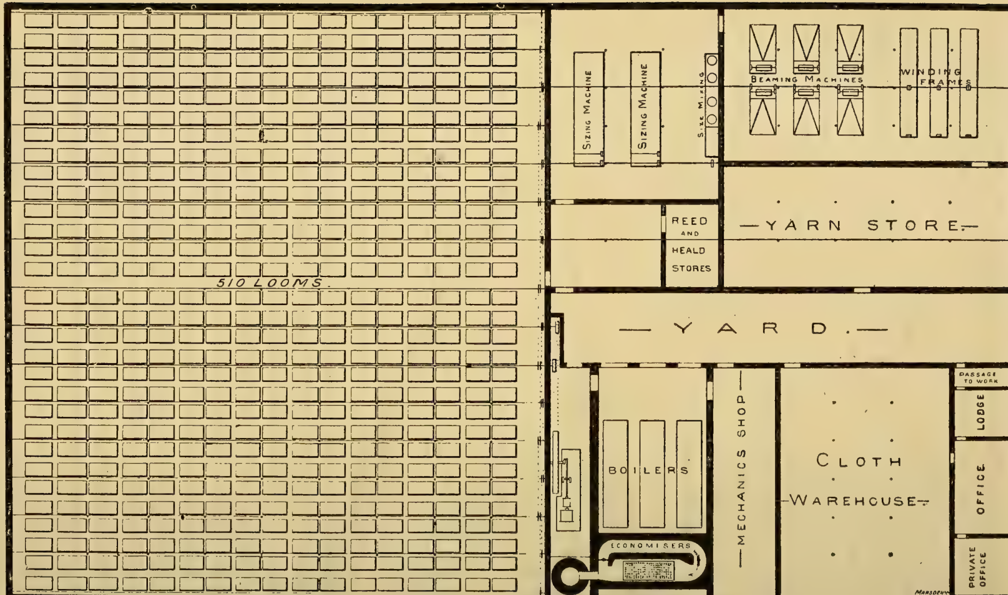


FIG. 182.—PLAN OF WEAVING MILL.

driving pulleys 15 inches diameter running 40 revolutions per minute. All the machines are driven from one main shaft.

The sizeing room is situated next to the winding room and provides ample accommodation for two sizeing machines and the usual size-mixing apparatus. The former are each nine-eighths wide and are arranged with 6 feet and 4 feet drying cylinders, with creels to hold six warper's beams, length of machine 32 feet 6 inches × 8 feet 6 inches wide. The pulleys are 13 inches diameter, running 200 revolutions per minute. These machines, as well as the size-mixing apparatus, are conveniently driven. Next to the sizeing room there are two spacious rooms for reel and heald stores, and for looming or drawing and twisting-in purposes. These latter are in direct communication with the weaving shed.

All the machinery is driven by ropes in the most direct manner possible, the engine being arranged to drive direct to two first motion shafts, from whence power is transmitted to each succeeding driving shaft by counter ropes and pulleys. From the main shaft, and connected with it by bevelled gearing, a line of light shafting runs parallel with and between each two rows of looms as set back to back, and which are driven from it. The driving pulleys for each loom are placed as direct as possible under each driving shaft. Two of the loom driving shafts are extended into the sizeing and winding rooms for driving the machinery contained therein, in the manner above stated.

The question has recently been raised whether by the system of rope-driving more power is not absorbed and lost in its transmission from the engine to the machinery than by wheel-gearing, which since rope-driving practically displaced it, has been considerably improved. Possibly the serious disadvantages of the latter system as they existed up to 1875 may have been reduced, or even obviated altogether in many important respects; but some of them, such as the cost of greasing, the filth incident to

this, the noise, and the liability to disastrous breakages, are essential to the system, and though they may be minimized, they cannot be removed altogether. It is charged against the rope-driving system that too much power is absorbed in dragging the ropes out of the grooves, and the increased friction caused by the weight of the ropes pulling the shafts heavily against their bearings. It is probable that the latter will be a matter that cannot easily, if at all, be removed, or even materially reduced, but the former by improvements in the form of the groove may be obviated altogether. It may, at all events, be assumed that the system of rope-driving did not jump into existence in its most perfect form, and that therefore if it has lost the leading position—which is not admitted—there is no reason why it should not easily regain it. But these and many others are points that will always require the careful personal examination of every person intending to commence business, for until progress ceases to take place, all competitive systems in every department are liable to undergo important modifications.

In the conduct of a large business, such as is implied by a mill like the one described, it sometimes happens that orders for what are termed lightly picked goods will be received, in working which the looms would overrun the preparatory department, if permitted, which would cause inconvenience, loss of time, and diminished production. In order to avoid this result a small engine is provided for overtime working of the preparatory department—especially the sizeing machines, without running the shafting and gearing of the other portion of the establishment. The steam left in the boilers, and which would otherwise condense during the night, is generally sufficient for this purpose, and is thus utilized. A mechanic's shop for making repairs completes the equipment of the establishment.

The boilers, along with the economizers and chimney, are in close proximity to the engines, and are arranged as com-

pactly as possible, whilst a large mechanic's shop is conveniently situated alongside. The coal space for the boilers is easy of access from the yard.

A spacious yarn store and cloth warehouse are provided, and have each direct communication with the yard for loading and unloading purposes.

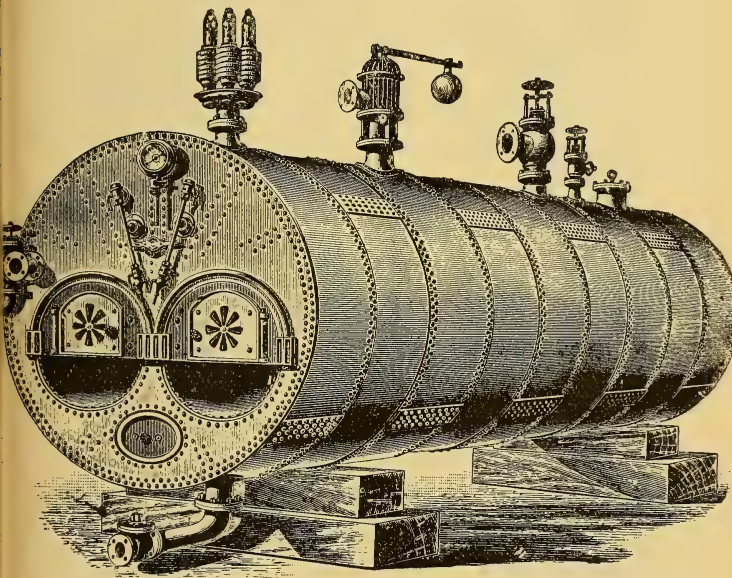


FIG. 183.—THE LANCASHIRE BOILER.

The arrangement of the shed generally is suitable for economical working and can be readily extended without very great cost.

We may now turn and look at these matters in a little more detail. The selection of a proper type of boiler is an important matter. Cotton manufacturing is in no sense a business that furnishes fuel as a waste or bye product

of any of its processes. All the fuel has to be purchased in one way or another. Therefore the type of boiler should be that constructed to give the highest degree of evaporative power from every pound of fuel consumed. There are many types of boilers, but the merits of these need not be discussed in the limited space that can be devoted to the matter here. It is enough to appeal to the general experience of the trade, and this has long declared the Lancashire boiler (fig. 183) is simple, efficient, and economical, whilst it can be easily cleaned and kept in order. This boiler, as will be seen from the illustrations given herewith, of the front view (fig. 184), and cross section, 185, contains two flues, extending the entire length. Each tube has its own furnace. The presence of two flues distinguishes the Lancashire from the Cornish boiler, which contains only one. The two flues give much greater heating surface than one, and thus more effectively utilize the heat generated. With a view to still further increase the steam generative power, the flues are fitted with what are termed Galloway tubes, shown in the cross section (fig. 185). These have long ago been proved of such advantage, that they are now found in almost every boiler of the Lancashire type by whoever made, as the patent right has expired. In addition to economizing the heat developed, these tubes facilitate the circulation of the water in the boiler. The boilers are of course fitted with the usual steam and water gauges, pressure indicators, blow-off taps, and the other appliances conducive to efficiency and economy. The internal construction of this boiler is shown in fig. 186, a longitudinal section.

Notwithstanding every device indicated in the construction of the boilers illustrated here, and of other types also, there is still an enormous waste of the heat generated, which passes into the atmosphere unutilized, and the fuel consumed to produce which is thus wasted. The steam boiler has hardly ever had that attention given

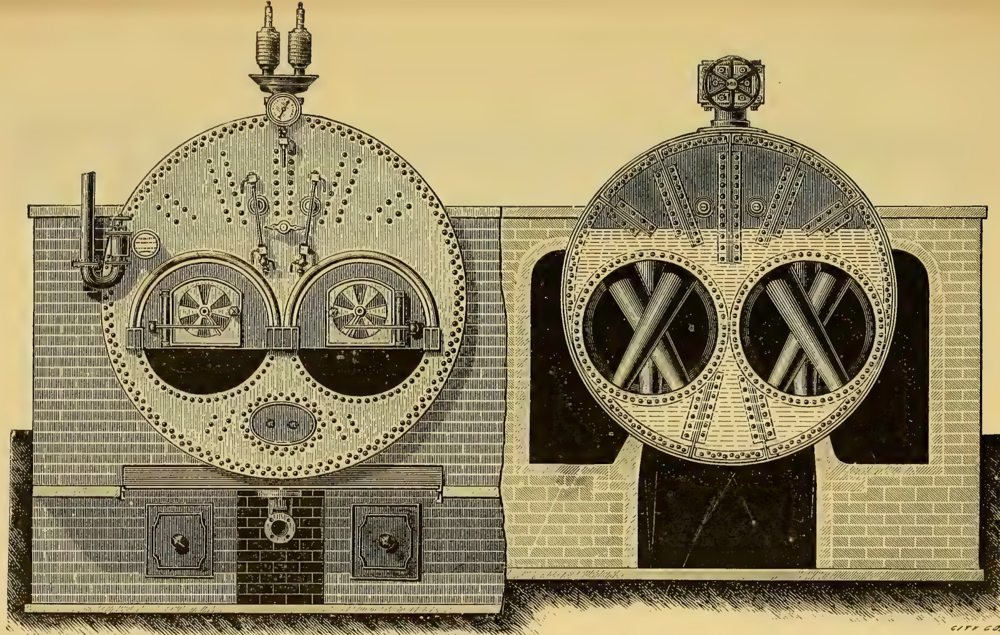


FIG. 184.—FRONT VIEW.　　FIG. 185.—CROSS SECTION.

A PAIR OF LANCASHIRE BOILERS, SEATED.

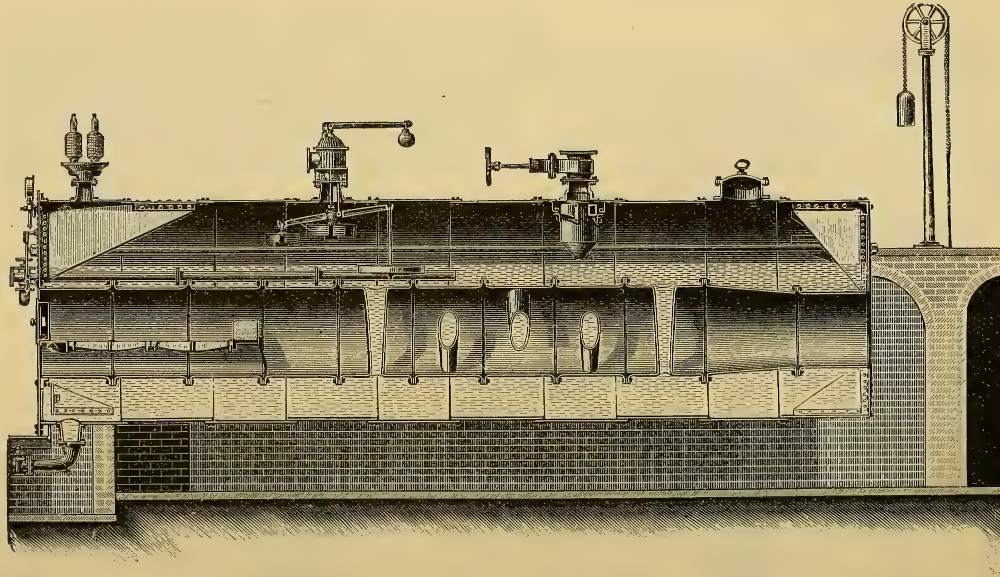


Fig. 186.—Lancashire Boiler; Longitudinal Section.

to it which its importance deserves, and which in the way of economy it will well reward. This neglect, however, seems likely soon to be remedied, as its turn for attention is beginning to be recognized. It has been seen that the wasted heat ought to be utilized, and attention is being closely directed to the accomplishment of this end. One method of doing this is illustrated in fig. 187, which shows an improvement in the construction of the furnace

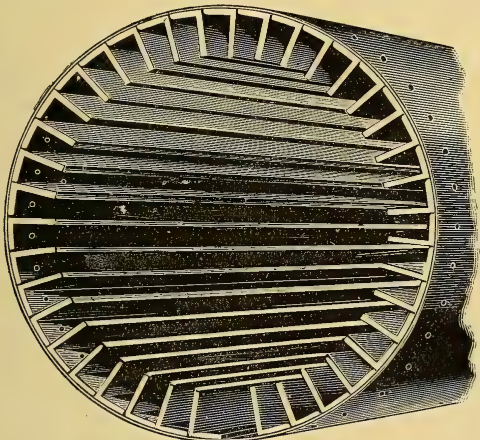


FIG. 187.—IMPROVED BOILER FLUE.

flue. The inventor recognizes that the air and gases developed in the boiler furnaces are heated to a temperature of from 1,700 to 2,000° F. This of course would fuse the entire furnace and its surroundings, were it not conducted to the water contained in the boiler, or allowed to escape into the air. Its escape into the air is not desirable; its absorption by the water is. It is unnecessary to do more than remark that water vapourizes and passes off in steam at 212° F. This occurs with the water in contact with the external surfaces of the furnace flues,

water of a lower temperature taking its place until it attains the same degree of heat, when it passes away in a similar manner. The whole volume of water the boiler contains thus becomes heated to the same degree, and the circulation goes on, the vapourized water passing into the steam space of the boiler, where it is stored until required by the engine. The point to be observed here is that the heated gases of combustion impinging upon the internal surface of the boiler flues, and whose temperature, as just observed, is from 1,700 to 2,000°, are rapidly reduced from that point to something near 212°, by parting with their heat to the water, the iron of the flue being the medium of conduction. Thus continuously the flue is lined with a thick film of comparatively cool gas throughout its entire length. This gas is a bad conductor of heat, and is almost impenetrable to the greater heat of the unchilled core of hot gases rushing along to make their escape through the chimney, and which thus carry away their valuable quality of heat, produced at so much cost, unutilized.

How rapidly this heat passes away will be seen when it is stated that a Lancashire boiler is generally 30 feet in length, and that the force of the draught or rate of the passage of air through the furnace and flues is about 650 feet per minute, thus giving only about three seconds of time for it to deliver its precious freight of heat to the water. This is totally inadequate for the purpose, even if we quadruple the time, in order to take into account the external flues of the boiler. The inventor, in order to capture the heat of the core of gases thus escaping, has lined the internal surface of the flue with angle bars or plates, which extend through the outer stratum of chilled gases into the hot core, and taking up its heat transmit it to the water in the boiler, iron being one of the best of heat conductors. The result of the experimental tests that have been made has been highly satisfactory, as also have those of a few commercial ones made in an immature stage of the invention.

But whatever may be the ultimate fate of this invention, it is in this direction of the economization of fuel that the manufacturer, and all steam users, should look for the attainment of a considerable advantage.

A new manufacturing establishment should be equipped at the outset with the most improved appliances, not only

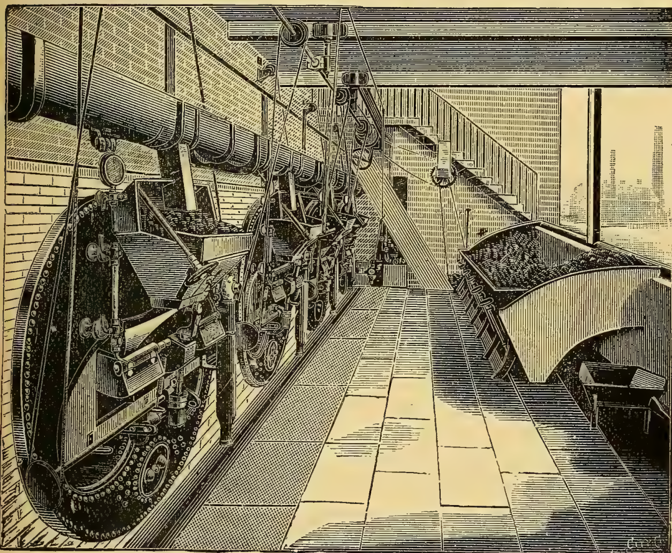


FIG. 188.—BOILERS WITH MECHANICAL STOKERS AND STOKER FEEDERS.

in steam generation, but in the economical use of the labour necessarily employed to produce it. Hence there have been invented as aids to this end quite a number of mechanical stokers of more or less merit. These, however, have not been in the main labour improvements upon the human manual stoker. They greatly lightened the oppressiveness of the stoker's labour in relieving him

from direct exposure to the glare and heat of the furnace, and dispensed with the requirement of skill on his part in the distribution of coal upon the fire. He had only to feed the hoppers of the stokers, and if he could throw the coal into them it could not go wrong. The iron arms of the stoker did the distribution.

Something, however, remained yet to be accomplished. If the furnace could be fed mechanically, why could not the hoppers? The inventor again, in the person of Mr. Thomas Wrigley, the principal manager of the extensive mills of Messrs. Fielden Brothers, Limited, Todmorden, said they could be, and forthwith proceeded to show how, by the invention of his automatic stoker feeder. The

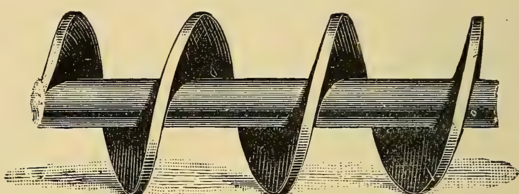


FIG. 189.—MECHANICAL STOKER FEEDER CONVEYOR WORM.

accompanying illustration, fig. 188, represents a series of boilers fitted with mechanical stokers, and the mechanical stoker feeder. Instead of tipping the coal, as usual, into and upon the floor of the "fire-hole" in front of the boilers, a series of large hoppers are arranged in front of them for the reception of the coal, and into these it is tipped from carts or waggons as the case may be. The hoppers have vents at the bottom and discharge into a channel in the floor. In this channel is fitted a large conveyor worm, a short length of which is shown in fig. 189, the revolution of which carries the coal to the end of the fire-hole, delivering it into a small hole, whence it is lifted by an endless chain of buckets forming the elevator. These discharge it into the longitudinal

half-tube extending along the front of the boilers over the hoppers of the mechanical stokers. This contains a second conveyor worm which brings the coal along, delivering it at orifices over each hopper. It will thus be seen that by this arrangement the coal is never handled from the moment it is received right through to its combustion. The invention thus dispenses at least with the services of one man to every three boilers. It also prevents all waste of coals by their getting into the ashes and being carted away before combustion. It thus becomes an important labour-saving appliance, as one or two men can take charge of all the boilers of a large establishment, and have less to do than when they had only charge of two on the old method. The conveyor worm is constructed of cast iron on a principle discovered or invented by Mr. Wrigley, by which a cast-iron worm, true in construction, and of any desired diameter or weight per foot, and of any length desired, and which can be used for a conveyor for either light or heavy substances, can be made. A worm of this kind has been a great desideratum, and Mr. Wrigley, by its invention, has placed the world of mechanics under an obligation.

Another important method of economizing the heat generated in the boiler furnaces is the economizer, as it is called, and an illustration of a set of which is given in fig. 190. These pipes are placed behind the boiler, the feed water for which passes through them. As the hot gases leave the boiler flues they impinge upon these pipes and heat the water contained in them to or over the boiling point, so that it does not lower the temperature of that contained in the boiler when it enters, and does not itself require to be heated up to boiling point by the furnace fires. This valuable adjunct to steam generation introduced by Messrs. Green and Sons, Wakefield, is so well known as not to require any further remarks.

An important part of the furniture of modern steam boilers are the valves. The now common practice of

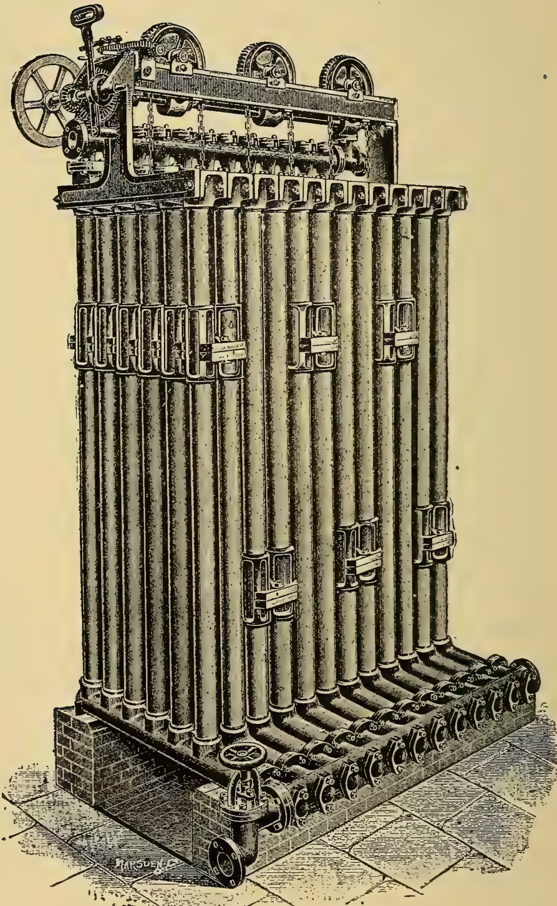


FIG. 190.—GREEN'S ECONOMIZER.

working at very high pressures, and the growing tendency to increase even these has to a great extent rendered obsolete the older types of valves, and their continued use in the changed circumstances not free from risk. To suit present needs the dead weight valve, which has done good service in its day, would need to be constructed in a very cumbrous form, and with a large increase of material. For a boiler working at about 150lb. pressure it requires over half a ton dead weight for a 3 inch valve. To meet the new requirements an improved valve has been designed (Fowler's patent) and placed upon the market by the makers, Messrs. Meldrum Brothers, Engineers, Manchester. This improvement is termed The Compact Dead-weight Safety-valve, and is illustrated in fig. 191. It consists of a hollow spherical casing resting on two seats, one face of the valve and one face of the seat forming portions of concentric spheres, so that the valve is left free to oscillate slightly on its seat, while its construction is such that the dead load required is only necessary to weight the annulus represented by the two valve diameters. This reduces the total weight of the valve by fully one half, whilst the separate pieces can be easily handled, and the valve be fitted by one man. This arrangement secures all the advantages of a dead-weight valve, whilst two outlets being provided, more rapid relief is afforded in the event of pressure rising too high.

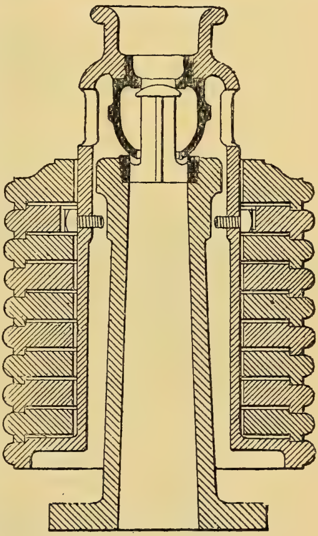


FIG. 191.

Another important safety provision is a combined high-steam and low-water safety valve, by the same inventor, and issuing from the same firm. It has been specially designed to give prompt warning of the running short of the water supply, and to automatically reduce the pressure in the boiler, by allowing the steam to escape at the same

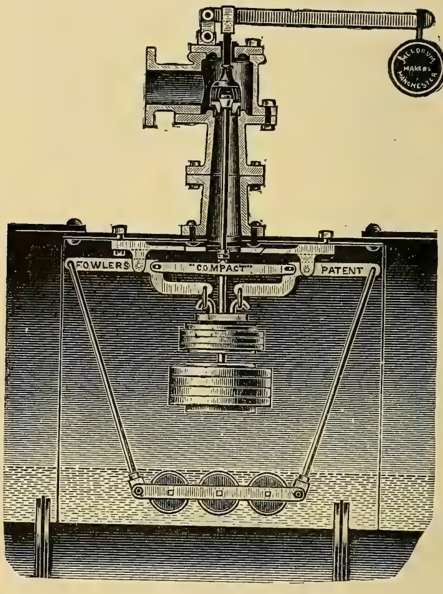


FIG. 192.

time. It consists, as will be seen from the accompanying illustration (fig. 192) of a duplex arrangement of levers, with a balance-weight suspended centrally above the float. The latter is composed of several cylinders suspended from two stirrups. These cylinders are filled with water, and require only a balance equal to their immersed weight. The water contained in them causes the valve to lift when

the surrounding water leaves the float. The construction of the float renders it easy to balance the parts for proper working before the valve is sent away from the makers, after which there is no requirement for readjustment arising from the decay of the parts as in the older types. The introduction of duplex levers renders the valve much more compact than before.

The engine next calls for a few observations. A good type, and one very suitable for a manufacturing establishment such as the one under description, is represented in the accompanying illustration. It is an elevation of a modern horizontal compound-engine, with condensor. It is fitted with grooved fly-wheel for transmitting its power by ropes. The cylinders are fitted with Corliss gear. They are arranged tandem fashion, or one behind the other. On the right of the illustration is shown a powerful barring apparatus, the function of which is to bring the engine into proper position for starting. Such engines as these show a wonderful advance upon those of twenty-five or thirty years ago both in construction and economy of working.

The equipment of a mill or weaving establishment with the gearing and shafting generally goes with the engine contract, though not always. Steel shafting is to be preferred, as it will transmit from 25 to 30 per cent. more power than the same weight of good wrought-iron shafting, and this weight avoided there is a corresponding reduction of the cost of driving. Shafts should be well supported, and carried in wide bearings not too wide apart. Bright shafting is more easily kept clean than dull shafting, and so slightly diminishes fire risks by not allowing the lodgement of cotton down or dust thrown off in the processes of working.

The pulleys should be of the unbreakable or wrought-iron type which are strong, light to drive, and repairable in the event of accidents occurring to them. An illustration is given of one of these in fig. 194. Where pulleys

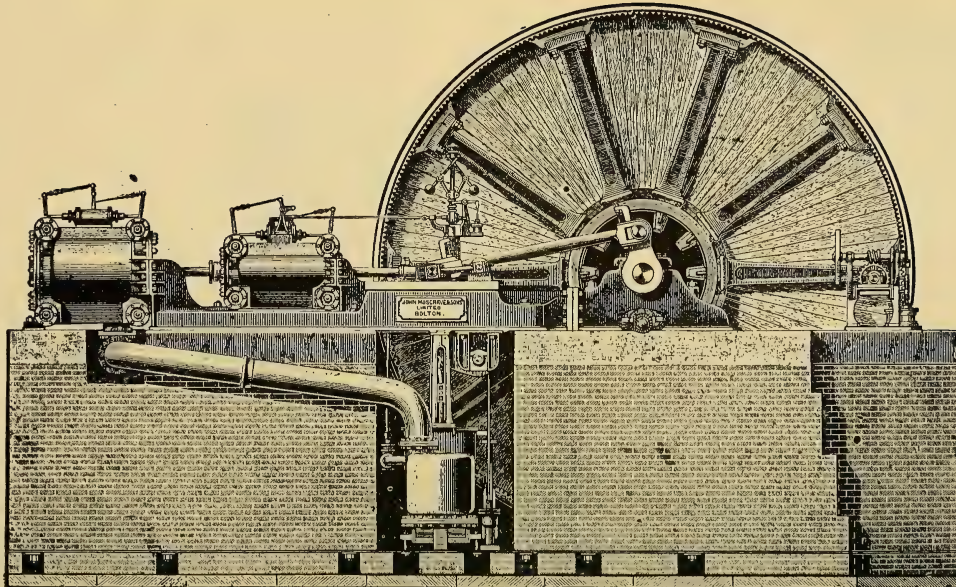


Fig. 193.—Horizontal Engine, to transmit Power by Ropes.

are placed in such a position that there is a probability of their being in the way of some requirement or other they should be of the kind called split pulleys, so that they can be removed and replaced with facility.

Of late years swivelling shaft bearings have come into extensive use and favour. This form of bearing is by far the best and most economical in use at the present time.

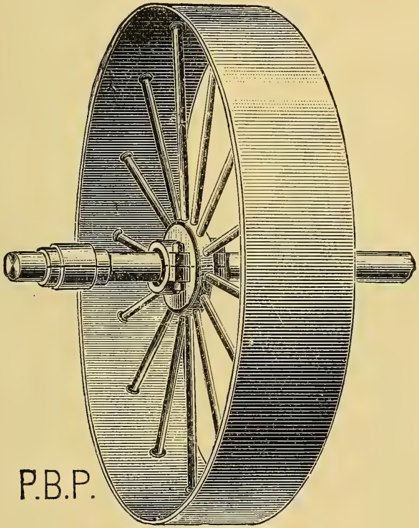


FIG. 194.

It is easily erected and adjusted vertically or horizontally, and afterwards needs little care, as it perfectly adapts itself to the alignment of the shaft it is supporting. Fig. 195 shows a wall bracket with adjustable swivel pedestal; fig. 196 exhibits a flat pillar bracket with adjustable pedestal; fig. 197 depicts a swivel adjustable pillar bearing to clip on round pillars; and fig. 198 shows a wall box with adjustable pedestal. The illustrations

represent the types of these bearings as made by the Unbreakable Pulley Company, West Gorton, Manchester. Adjustable bearings ought to be used wherever economy of driving is a consideration. Unless the equipment of the establishment in shafting and gearing be well done a loss of power and a waste of lubricants takes place, whilst

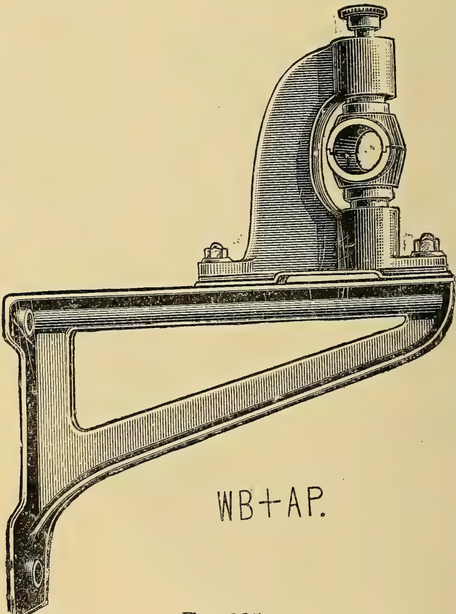


FIG. 195.

the liability to breakdowns, with the trouble and expense incident to them, is greatly increased.

Power is transmitted from the prime mover chiefly by three methods: wheel-gearing, belts, and ropes. From the early part of the century until well on in the sixth decade gearing was almost solely employed. It had, however, many serious defects, including great liability

to breakdown. About 1868 the attention of engineers in this country was attracted to the fact that in America it had become common to transmit power from the engine

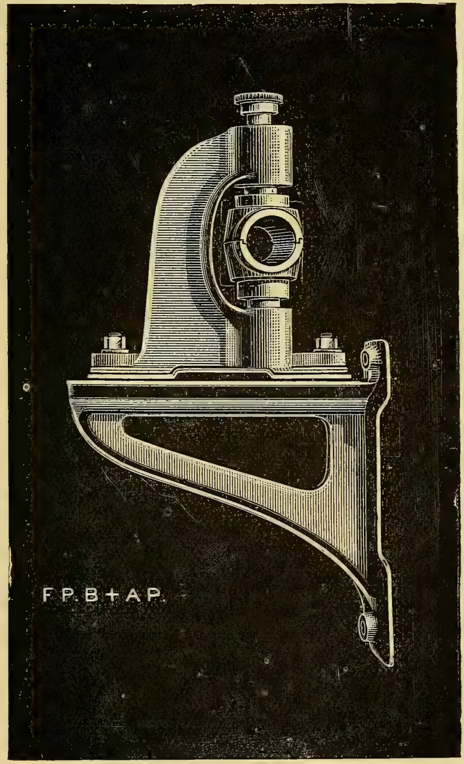


FIG. 196.

to the first driving-shaft by means of a large leather belt, and thence by other belts to successive shafts until the machinery was reached. This began to be regarded with considerable favour in the English manufacturing districts,

and was adopted in a number of instances. In the autumn of 1875 a Bolton gentleman, Mr. William Bamber, a cotton

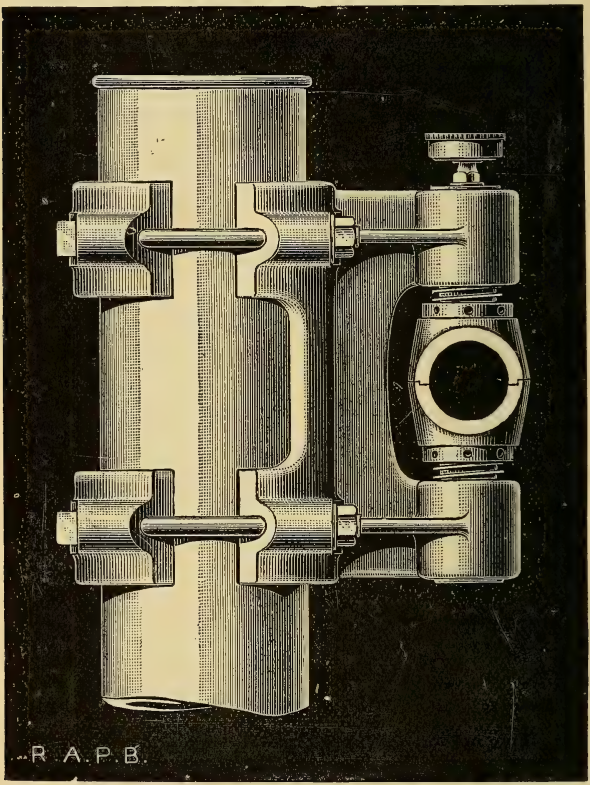


FIG. 197.

spinner, was spending a brief holiday in the neighbourhood of Dundee, in Scotland, when happening to enter a small flax or jute mill in the country, his attention was arrested by the fact that the power was being transmitted from the

engine to the first shaft by means of ropes running in grooved pulleys, which had taken the place of the usual spur gearing. As a practical man, the full importance of the advantages of the system struck him at once. His mill in Bolton having just previously been destroyed by

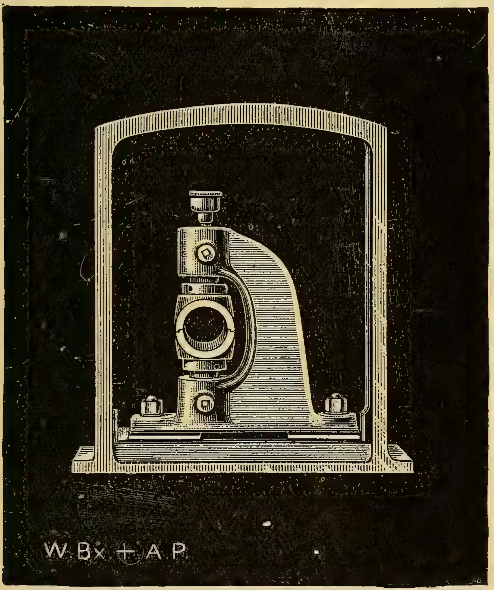


FIG. 198.

fire, and being then in course of re-erection, he instantly decided upon adopting the new method. Communicating with his engineers, Messrs. John Musgrave and Sons, Bolton, he explained his desires, and they after some hesitation as to the wisdom of the new departure, carried his views into effect. The result was highly satisfactory. Soon after its completion the present writer was invited

to inspect the new system, and was so pleased with it that he made a careful examination, and gave publicity to it in a journal with which he was then connected. The new system attracted wide attention, and excited a considerable amount of interested opposition. Its merits, however, were so evident, that this was soon silenced, as spinners and manufacturers would have nothing else. It has since been adopted in almost every new mill that has been erected. In a few cases the two systems of spur gearing and ropes have been combined. On the whole the introduction of the system has been an improvement of inestimable value. The writer has since learned that it owed its revival—for it is really an old system—to a Belfast firm of machine makers, who patented it, but did not push its adoption probably through becoming aware that the patent was invalid from previous use.

Hemp and manilla ropes were at first employed, but cotton was soon tried, and found to possess better wearing qualities than any other material. The result was that cotton soon became of general use in the manufacture of driving ropes.

The transmission of power by ropes is a use which calls for a modification of the usual method of construction, as several new factors affecting the value of the rope and its durability enter into the problem. An ordinary rope is made to bear a heavy strain mainly arising from a direct pull. The rope used in the transmission of power has this to do and something more, namely, to submit to constantly recurring flexure and straightening again as it bends over the pulleys and is straightened out again in its passage from one to the other. This begets an enormous amount of friction amongst the fibres of which it is composed, which has a tendency to pulverize them. Those fibres lying on and forming its surface have also to bear the frictional contact with the grooves of the pulley, of entering them and being dragged out. These form great additions to the burden of an ordinary rope. The superior

flexibility of a cotton rope undoubtedly is the cause of the preference shown for it for this purpose, but even the cotton rope in its best ordinary form left much to be desired in the way of increase in the qualities of flexibility and durability, and inelasticity.

Seeing these facts, Mr. Thomas Hart, of Blackburn, the present head of a very old established firm of rope-makers, set himself to solve the new problem. This he accomplished by the invention of the well-known "Lambeth Rope," so named from the Blackburn works of Mr. Hart. This is a cotton rope of peculiar construction. It is composed of four strands, each strand consisting of a number of cotton yarns run out parallel to one another at a uniform tension, so as to give equality of length to each. These threads form the core of the strand, and one intended to bear the whole of the tensile strain that it has to carry. The strand is not twisted, or at least not more so than to bring the yarns together. The absence of the usual twist leaves the strand exceedingly flexible. Around this untwisted strand of yarn an envelope is thrown composed of ten twisted cords of cotton yarn, which are wound helically around the strand, enclosing it in such a manner as to form for it a perfect shield, which preserves it from wear and maintains its flexibility.

Four of these are combined in one rope. The central cavity that would be left when four cylindrical strands were twisted together is filled by three cords. It will be obvious from this description, and the illustration (fig. 199), that the cores of the strands will receive all the tensile strain, whilst the envelope or shield will bear all the wear and tear of the frictional contact of the rope with the grooves of the pulley. The core threads are arranged in the best possible manner for developing a far higher degree of tensile strength than has ever been attained before, and with the least injury to the component material. The envelope, being relieved of all strain, much more

effectually resists frictional wear. The combination of strand and cover gives the maximum of durability, strength, and flexibility yet attained in ropes for this purpose.

This construction is extremely well suited for transmitting power. As it hardly stretches at all in work after being put on the pulley, its great flexibility enables it to bend easily to its work in passing round the periphery of the pulley, and to straighten out again when coming from it. Ropes constructed on the ordinary method tend to pulverize and soon break from this cause,

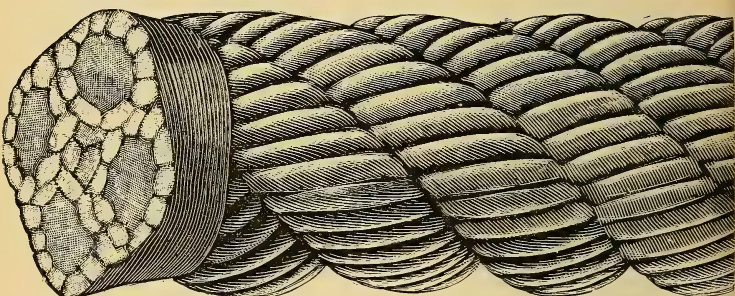


FIG. 199.—THE LAMBETH DRIVING ROPE.

owing to the bending backward and forward destroying the cohesion of the particles of the fibrous material of which they are composed. In some recent tests it required a weight of 13,260 lb. to break a rope of $1\frac{1}{2}$ in. diameter. With a strain of 1,775 lb. the same rope stretched only 2·80 per cent. The general working load of such a rope is much less than this. The durability of ropes are of course considerably affected by the conditions and circumstances in which they work. There are instances of this rope having been in constant use over ten years, and which still appear to be as good as when first installed.

CHAPTER XII.

Miscellaneous Matters in the Equipment and Organization of a Cotton Manufacturing Establishment.

An East Lancashire cotton manufacturing establishment selected as typical of the trade.—Classification of cotton goods.—A selection for one mill necessary.—A mill for the production of goods for Eastern markets described.—Blackburn the centre of this industry. —The construction of the mill and the concurrent provision of engines and machinery necessary.—Mill stores.—The selection of proper qualities of yarns and production of sample cloths of primary importance.—Reception of yarns and subsequent passages through processes indicated.—The Yarn Store: described.—The Purchase of Yarns: the qualities to be looked for.—General Qualities of Yarn: the necessity of selecting proper standards and preserving samples.—Testing of Yarns: permissible amount of variation of counts; coarse or fine counts and moisture.—A Standard Cotton and Yarn Tester: crude methods of testing unreliable and unsatisfactory.—A scientific standard of dryness from the International Congress of Turin.—A scientific yarn tester for damp yarns, *illustrated*.—Percentages of loss on 1 lb. of yarn.—Points to be taken into consideration.—Testing Counts: should be carefully performed; its great importance.—Yarn Testing and Inspecting Machines, *illustrated* and described.—How to use them.—Preservation of samples.—How to ascertain the amount of twist by it.—Test for elasticity, *illustrated*.—The ordinary method of testing defective.—A twist tester, *illustrated*.—Testing by calculation the best method of getting uniform weights of cloth.—Testing Yarns for Strength: testing by hand, and its advantages in showing the presence of other faults.—Thick and thin places, "neps," "crackers," their origin, etc.—The lea strength tester, *illustrated*.—The only satisfactory and perfectly reliable test is derived from the careful examination of a yarn in practical work.

In this essay the writer will follow the plan adopted in his preceding one, the emphatic approval of which he is pleased to acknowledge, and devote the following pages to an exposition of the means whereby, in his opinion, from the materials employed, the highest quality and the greatest amount of production may be obtained at the

smallest cost. Again, as in the spinning division, there will be found no antagonism in the methods: that which conduces to one result being equally favourable to the other.

It may be assumed that the reader who has carefully perused the preceding chapters will have gathered a sufficient knowledge of the machinery required to equip a cotton manufacturing establishment in almost any branch of the trade. The description given, however, so far as it has any specialty, applies in the main to the great weaving district of East Lancashire. Assuming that one of the branches of the trade carried on therein has been selected, we may proceed to describe its equipment and general organization.

The manufacturing branch of the trade is more subdivided than the spinning branch, and its productions do not lend themselves to the plan of grouping in classes so easily as yarns. They will, however, admit of being roughly divided into five or six great groups, which again will each require to be subdivided into several smaller ones. These are:

1st. Domestics, mediums, and long cloths.

2nd. Printing and finishing cloths.

3rd. Shipping goods for Eastern markets: shirtings, jaconets, mulls, and bordered cloths.

4th. Coloured goods: a large variety for home and shipping.

5th. "Fancy" goods, so called from being made in complex weaves, and with the aid of elaborate shedding and picking mechanism.

6th. Fustians: these consisting of moleskins, cords, velvets, velveteens, &c.

It is not necessary at this point to enter into or even enumerate the subdivisions; they will be more properly noticed, if necessary, later on. The adoption of any one of the above divisions will govern the decisions of the intending manufacturer in the selection of locality in which to

carry on his operations, and the structure of mill and machinery for producing the same. It will at the same time compel and confine the commercial part of the business into special and appropriate grooves.

Within the prescribed limits of this work it would be clearly impossible to treat each division in elaborate detail. A selection, therefore, becomes necessary. The third division will afford the best choice, not only on account of its being the most important and varied in its productions, but because it will more readily admit of digressions in either direction to notice the specialities of machinery, processes, and productions, as they may from any cause require attention.

The great district of which Blackburn is the centre, is the chief seat of the industry represented in the third division, and its selection demands that our ideal establishment should be placed within its pale. The exact locality should be one in which an abundant supply of trained and experienced hands are available, and no local physical obstacle should impede access thereto. Supply and demand in relation to labour should operate as freely as possible. Other things being equal, the choice of the labour market should be as open to the owner as to any of his competitors. If any of these points are sacrificed care should be taken that full compensating advantages are secured in permanence.

The weaving-shed and the details of its structure have been sufficiently described in the preceding chapter.

Parallel with the construction of the weaving-shed, or at least immediately antecedent to its completion, it will be necessary to consider the commercial side of the business, because the arrangements required ought to be as far as possible perfected before they are needed to be set in motion.

It is assumed that the engineering work necessary to fully and properly equip the weaving establishment with boilers, engines, shafting, gearing and other essentials,

have been duly contracted for, and such conditions made as to preclude delay in its execution. If this has not been done, loss may occur owing to the capital previously expended being rendered unproductive for a longer period than ought to have been the case. The same remarks will apply to the machinists who are to supply the preparation machinery and the looms. Indeed, delay at any point from any cause, will necessarily paralyze work at every point and involve loss. Assuming that these points have been attended to on the lines laid down, little will remain to describe of its mechanical equipment but what will come before the reader in an incidental way.

The next requirement will be the provision of the mill stores necessary to equip and set the preparatory machinery and the looms to work. These will consist of healds, reeds, pickers, picking bands, strapping for driving-belts and other purposes, brushes, oil, sizeing materials, etc.

The next step is one of primary importance, namely, the selection of the proper qualities and purchase of yarns. This must be governed by the character of the business intended to be pursued. It has already been assumed that the branch selected is the Blackburn trade, the manufacture of goods mainly intended for exportation to the great markets of Eastern Asia: India, China, Japan and subjacent countries. These consist of T-cloths, sheetings, shirtings, jaconets, mulls, and cotton cambrics. But this would be far too extensive a field to endeavour to cover, as each of the three first classes of articles require to be divided again into three sub-classes, namely, low, medium, and good qualities; whilst in shirtings, jaconets and mulls, there are sub-varieties, namely, shirtings, jaconets and mull dhooties: that is, shirtings, jaconets, and mulls having taped, plain-coloured, or coloured striped or figured borders. Then again, besides these varieties there are the same in narrow, medium, and wide makes, and in these only the qualities for which proper provision has been made in the widths of the looms, can be undertaken.

These various cloths require different counts of yarns, and in their subdivisions different qualities of the same counts. In the latter it is highly inconvenient to work them together on account of the risk that exists of the different qualities of the material getting mixed. This has led to manufacturers adopting one or other of the ordinary subdivisions, and to make accordingly, good, medium, or low qualities, as the case may be. The section having been decided upon will dictate the counts and quality of the yarns to be purchased. As a rule persons beginning manufacturing will have to undertake the responsibility of these decisions with but little guidance from actual contact with the market, because no merchant would give them an order without first seeing samples of their production, and samples cannot be produced without manufacturing being actually commenced. To any application for orders under such circumstances the merchant would reply, "Show me samples of what you can make." And very properly so. But in commencing business it is more usual to engage the services of an agent of experience and reputation, and having a good connexion, such a one being able to offer valuable advice at the beginning.

Assuming that these matters have been decided, and that the supply of yarns has been bought, it is brought into the establishment in large skips or baskets, holding from 250 to 300 lb., and is warehoused in the yarn store. From here it is delivered to the winders; next, upon bobbins, to the warpers, and thence upon beams to the sizers. After its passage through the latter process, it is delivered upon loom-beams to the drawing-in or looming-room, for the drawers or twisters to attach the healds and complete its preparation for the loom. From here it passes to the weaving-shed, in which, so far as the manufacture is concerned, it is completed. It is only in rare instances in this country that bleaching, dyeing, or printing is carried on in the same establishment. Weft yarns, as a rule, not requiring any preparatory treatment, pass

directly from the spinner to the weaver, and when received are simply warehoused in the weft-store, whence they are delivered in small cans or baskets to the weavers in the loom-shed. When the cloth is woven it is cut into certain marked lengths called pieces, and sometimes collected from the weavers by a labourer, carried into the warehouse, and entered to the respective weaver's credit. In other cases the weavers deliver the cloth to the warehouse. After careful examination, it is made into bundles, and despatched to the agent or merchant in Manchester. With this prelude we may now speak of a few preliminary matters before proceeding to treat of the conduct of the various processes which will require a chapter to themselves.

The Yarn Store.—Assuming that a weaving mill has been constructed, approximately, at least, on the lines laid down in a previous chapter, we may offer a few remarks on the yarn store. This should be a cool apartment on the ground floor, or a cellar with plenty of light, though not admitting the rays of the sun in a direct manner to any considerable extent. In the matter of dryness it should be a little below what may be called "par." Let it be assumed that 100 represents natural dryness; 0 = zero, a humid state of the atmosphere that would imply rain; the condition of a yarn store would be best at about 60-70. There is something in slight humidity and coldness that tends to produce consolidation in cotton yarns, and to make them work better both in the winding-room and the weaving-shed. Neither twist nor weft that have been exposed for several days to the high temperature of the winding-room or the weaving-shed work nearly as well as that which has been newly supplied from the yarn store.

The Purchase of Yarns.—It is always best to purchase yarns that are of a reliable character, both in the points of quality of material and regularity of counts, because those which vary in either of these respects will at one time or other involve the user in loss and trouble; in the latter

when the counts run down, and in the former when the variation renders it unfit for the purpose intended. It is a good plan to find several spinnings that are satisfactory, and as nearly alike as possible, and to work these as exclusively as circumstances will permit, because by changing from one mark, or spinning to another without due care, all sorts of irregularities are induced, the bad consequences of which the best management cannot obviate. The cloth produced will thus get a bad character, and though actually fluctuating in quality, will always have to be sold at a degraded price. There is another reason why several spinnings should be discovered about equal in quality: it is not desirable that a weaving establishment purchasing its yarns should depend upon one or two spinnings which circumstances, such as forward engagements to other customers, a strike, a breakdown, or a fire, might cause to be taken from the market at any moment.

General Qualities of Yarns.—It is very important that a proper standard of quality should be selected for the yarn it is intended to use, and that samples of this should be preserved and kept perfectly clean. Subsequent purchases should be regularly compared with these samples and not with each other in succession. In the latter way considerable degradation is liable to occur, owing to the shades of difference, though in each separate case the change may be imperceptible, becoming in the aggregate very great. The qualities that should be looked for are the proper shade of colour, cleanliness, evenness, strength, and a uniform amount of twist. When in these respects the different lots prove equal to the standard sample, and have been found correct in counts, and gross, tare, and net weights, and tested for "damp," they may be passed for use.

Testing of Yarns.—One of the most important matters in connection with a manufacturing establishment is the careful testing of the yarns that are purchased for its use. The first point to be regarded is the counts, which ought

to be full to the number purchased, and should neither go under nor over more than half a hank. In medium counts there is no valid excuse to be offered for a wider variation. Some years ago it was a common practice amongst spinners, say of 32's, to assume that they had perfectly complied with the terms of their contract if they delivered 31's, and they would have been prepared to affirm that there was but little ground of complaint when 30's were delivered: a deficiency of over 6 per cent. in length from the nominal point. This in the halcyon days of big profits was a matter that could be ignored by manufacturers: but of late, say during the past fifteen years, owing to the severity of competition at home and abroad, this cannot be done any longer by those who have the slightest regard for the maintenance of their solvency, let alone making a living out of their investment and labour. The exactitude of manufacturers in this respect has brought about a change in the habits of spinners, but which it is regretful to say has only substituted one evil for another. The method now adopted is to spin yarn two or three hanks above the nominal counts and by placing it in circumstances favourable for the absorption of moisture, say in shallow wicker baskets, in a damp, steamed, or well-watered cellar, to bring it down to proper counts by the absorption of moisture. The water thus surreptitiously added is invoiced to the manufacturer, as, and at the price of, yarn. The natural affinity of cotton for moisture is thus taken advantage of very extensively to commit what is little better than a fraud.

A Standard Cotton and Yarn Tester.—The dampness of cotton and yarn is an old cause of complaint amongst spinners and manufacturers, and has been the origin of innumerable disputes in matters of account between buyers and sellers. Crude methods have hitherto been resorted to in order to test yarns for adulteration by water. A weaver's canful of weft or twist, about 5lb., has often been taken after carefully weighing and dried upon the boiler or

in the engine-house, or any other place in which the temperature was high, and after the moisture has been driven out it has been submitted to the atmosphere for a greater or less time to re-absorb what it could get. At other times whole skips of yarn have been so treated. Many other rude devices to obtain the same end have been tried, but in all there has been a want of care and accuracy in conducting the experiments, and above all of uniformity in details of weight, exposure, temperature, and atmospheric exposure, so that the knowledge that has been gained has been too fragmentary to admit of classification and the deduction of useful conclusions. Practically, therefore, no purpose has been served by them beyond the immediate one which caused them to be undertaken. The want of a sound, reliable, and scientific test has therefore, until within a few years ago, gone ungratified.

Before satisfactory conditions can be arrived at it is necessary to establish a standard of dryness upon which all agree. In conditioning houses upon the Continent this point has received a great deal of attention, especially in connection with the conditioning of silk, the most valuable of all the textile fibres. From this the discussion has travelled to woollen, cotton, jute, flax, and hemp, and the subject has been, approximately at least, settled in an authoritative way. The methods by which these conclusions were reached cannot, however, be detailed here. The point started from, however, was absolute or chemical dryness, from which natural absorption was allowed to commence. The result of numerous experiments was found to be as stated at the International Congress held in Turin in October, 1875, that the different fibres in the state of yarn absorbed moisture according to the following percentages:

Wool yarns	$18\frac{1}{4}$ per cent.
Jute "	$13\frac{3}{4}$ "
Hemp "	12 "

Flax ,, ...	12	per cent.
Silk ,, ...	11	,,
Cotton ,, ...	$8\frac{1}{2}$	,,

These conclusions might not in the humid climate of England be found to agree with facts in the closest manner, as undoubtedly, with the greater amount of moisture regularly present in our atmosphere, all of these various fibres would take therefrom a slightly greater percentage, which would require to be allowed for, or, perhaps, necessitate a different standard.

Chemical dryness, it may be observed, is obtained by exposure to air heated to 212° F. If, therefore, to the weight obtained after subjection to this test the above percentages be added, natural dryness may be said to be fairly obtained. Any difference between the weights thus obtained and the original one will exhibit with a very close approximation the amount of moisture that has been introduced for fraudulent purposes. What has been wanted has been a ready means of performing this test, and this has been provided by a gentleman long connected with the trade in an invention that answers the requirement in this respect admirably. The appliance is a shallow rectangulur copper steam chest or boiler, having a corrugated upper surface that will receive twist cops or hanks as shown in the accompanying illustration. The boiler is fitted with a condenser in which the steam is condensed and the water returned to the boiler. Hence there is no trouble in maintaining a supply of water. The whole is heated by a Bunsen burner. The yarn to be tested—1 lb., the tester being arranged to treat that quantity at a time—having been placed upon the corrugated top, the burner is lighted and the water quickly raised to the boiling point. By exposing the yarn in this manner the free moisture it contains is thrown off at the following rate: In three hours it is brought within 1 per cent. of chemical dryness, in two hours within 2 per cent. As the third hour

is almost invariably within 1 per cent., two hours' exposure is sufficient for comparative tests.

In order to facilitate the use of the tester, its inventor has compiled the following table of percentage of loss on 1 lb.:

1 lb.	loss	2 oz. =	12·5 per cent.
1 lb.	,,	$1\frac{7}{8}$ oz. =	11·7 ,,
1 lb.	,,	$1\frac{3}{4}$ oz. =	10·9 ,,
1 lb.	,,	$1\frac{5}{8}$ oz. =	10·1 ,,
1 lb.	,,	$1\frac{1}{2}$ oz. =	9·4 ,,
1 lb.	,,	$1\frac{3}{8}$ oz. =	8·6 ,,
1 lb.	,,	$1\frac{1}{4}$ oz. =	7·8 ,,
1 lb.	,,	$1\frac{1}{8}$ oz. =	7·0 ,,
1 lb.	,,	1 oz. =	6·2 ,,
1 lb.	,,	$\frac{7}{8}$ oz. =	5·4 ,,
1 lb.	,,	$\frac{3}{4}$ oz. =	4.7 ,,
1 lb.	,,	$\frac{5}{8}$ oz. =	3·9 ,,
1 lb.	,,	$\frac{1}{2}$ oz. =	3·1 ,,
1 lb.	,,	$\frac{3}{8}$ oz. =	2·3 ,,
1 lb.	,,	$\frac{1}{4}$ oz. =	1·5 ,,
1 lb.	,,	$\frac{1}{8}$ oz. =	·8 ,,

One per cent. loss or gain on any standard fixed upon is on 20,000 lb. at 6*d.* = £5, at 9d. = £7 10*s.*, at 1*s.* = £10. From these figures the value of a standard tester will be manifest. The tester occupies only a small space, being 21 in. by 10 in. and 8 in. deep. It requires very little attention, and a small amount of gas keeps it to the boiling point. It is illustrated in fig. 200.

In justice to sellers of yarns it must be observed that buyers who resort to this test will require to take into consideration and make allowance on several points that have not yet been noticed. Honest single cotton yarns by the dry air test will lose 8 per cent., by the tester in two hours 6 per cent., or say 1 lb. in two hours will lose 1 oz. In doubled yarns a larger allowance will have to be made, as the doubler is expected to return the same

weight as that delivered to him, and to hold him to this standard would be to make no allowance for waste in the process of doubling; and the allowance on this account will require to be greater in the case of coarse yarns than fine ones, because of the higher proportion of waste resulting from working them. And further: all

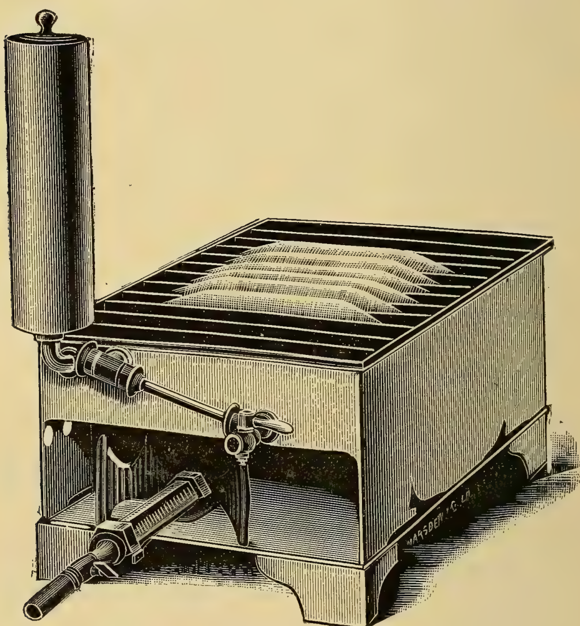


FIG. 200.—YARN TESTER FOR DAMP.

tests, it must be observed, can only be comparative, because of the fact that various classes of the same fibres differ in their hygroscopicity or power of absorbing moisture. Thus in cotton, for instance, American, Egyptian, and Surat cottons after being dried would probably be found to absorb different proportions of moisture, and

similarly the yarns made from them. Only experience and conscientious handling of this admirable instrument will, however, bring these points into full view.

This little invention will be found to be of great utility in all branches of the textile industries, and no doubt the principle it embodies will be found capable of even wider application.

Testing Counts.—Wrapping or testing, to discover the counts, should be very carefully and honestly performed, in justice to both buyer and seller. For this purpose it is best to use a modern or improved reel, with a traverse motion for distributing the yarn upon its periphery instead of allowing it to run in successive layers upon each other, thereby sensibly enlarging the circumference and causing the leas to yield an incorrect result. This deceives the operator and gives rise to annoyance by causing claims to be made that can be shown to be founded upon an error.

The importance of attending to the counts of yarns, is of the greatest moment; because if the yarn should be purchased for 30's and should come in 28's, the loss in the length of thread will be 7 per cent.; and if 29's, 3½ per cent. Supposing 40's be purchased and 38's received, the loss will be 5 per cent., and 2½ per cent. with 39's. Yarn which is more than half a hank away from nominal counts should not be passed without a claim for compensation, and if this cannot be obtained, care should be taken that either the price paid for it should be sufficiently low to afford compensation for the loss as compared with those correctly spun, or the latter should be purchased in preference. Suppose a sufficient quantity of yarn to have been purchased for manufacturing 1,000 pieces of cloth, and that the same has been invoiced to the manufacturer, but that either by excessive moisture, coarseness of counts, or both combined, there is a loss of 5 per cent. The yield will then only be 950 pieces, the remaining weight either having gone into the 950 pieces, making them better than contracted for, or otherwise having evaporated in moisture.

In either case it is a loss to the manufacturer. This in a weaving mill containing 500 looms, making six pieces per loom per week, will be equal to a loss of 7,500 pieces, representing, at 6*s*. per piece, a sum of over £2,150 per annum. This sum, it will be obvious, means the difference between success and failure.

Patent Yarn Testing and Inspecting Machine.—The best machine for testing the counts that we have seen is the patent yarn testing and inspecting machine manufactured by Messrs. Henry Wallwork and Co., Charter Street, Manchester. This machine enables those interested in the buying and selling of yarns to thoroughly test their qualities not only in the counts but also in the evenness, and to keep a visible record, by which they can also make a comparison with the same or other yarns at any time. This machine supersedes the ordinary wrap reel. Instead of winding the yarn to be tested on a reel, it is wound helically on a flat piece of blank cardboard, so that each convolution lies close to the board, and there is no overlapping; every layer is therefore of precisely the same length, and separate from all the other layers. Lying against a black background, every portion can therefore be easily seen and all the flaws or bad places instantly detected. We give two illustrations of this improved reel.

Fig. 201 shows the machine as used for obtaining the ordinary lea for weighing to determine the counts. It will be seen that a vertical standard carrying all the mechanism is secured to a good wooden base. The shaft to the right carries at its end four double prongs, or clips, into which the black cardboard is inserted, as shown in the illustration. This shaft also carries a worm wheel working into the indicator dial for registering the number of revolutions. A second shaft, to the left of the vertical standard, and driven from the first shaft by means of a cord, is screwed at its projecting end, the pitch being sixteen threads to the inch; on this screw hangs loosely the

handle for guiding the thread, seen in the illustration, which travels along as the screw revolves. When the handle has traversed the whole length of the screw it can be lifted and put back to the other end at once, when it will be in a position to start again. In this manner the convolutions of the thread are laid nearly side by side, and when the lea, consisting of 80 threads, has been wound, the board is full. The number of turns are counted by the dial and pointer in the usual manner. To take off the

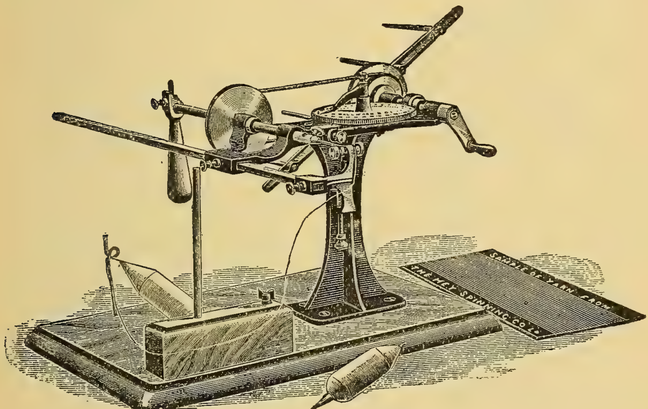


FIG. 201.—YARN TESTER FOR COUNTS.

lea, all that is required is to slide the template out of the clips, when by bending a little the threads are easily removed.

When it is desired only to inspect the yarn, it is not necessary to lay the threads so closely together as it is when winding for the lea; in this case, then, the cord seen in fig. 201 is put on a larger pulley, the effect of which is to turn the screw faster in comparison with the template, and so spread out the threads more. In fig. 201 a card is shown at the base of the machine filled with yarn;

in fig. 202 a similar card is shown with the yarn wound for inspection only. In this case the distance between the threads is about an eighth of an inch; all the defects, such as knots, snarls, dirt, or soft places, will be very well shown up. These cards offer a very convenient means of keeping samples for future reference or comparison, or for comparison of one maker's yarn with another. In taking samples for comparison, or for keeping, the ends of the cards should be gummed, so that when the yarn is once placed upon them it will retain its position. The machine is arranged to wind from spools, bobbins, or cops. By means of the long rod attachment, seen in fig. 202, the machine can be arranged to test the elasticity of yarn. For this purpose the rod is fixed as shown, and the yarn is secured to it at one end and to the arm working on the screw at the other, the length of thread between the two terminals being about 12 in., or any other suitable length. The pointer is set to zero, and the handle then turned as before; the loose arm moves up the screw at a known rate, and when the yarn breaks, the amount of stretch is registered on the dial. The stretch may be registered as so many sixteenths of an inch per foot, or in percentages, or in any other way that may be desired. It should be mentioned that the tension of the thread, while under this test, is prevented from exceeding a certain amount by means of a small weight attached to the end.

Again, another use to which this machine may be put is to determine the amount of twist in doubled yarn. For this purpose the long rod seen in fig. 202 is reversed, and the doubled thread is clamped by the specially-prepared end of the screwed spindle. The pointer on the dial is set to zero, and the handle then turned as before, until all the twist has been taken out, when the number of turns made is registered by the dial; the length of yarn operated on must be known in order to determine the number of twists per inch, so that the bar is marked to give one inch, two inches, or three inches, as may be desired. In

very fine counts the twist can be followed up by a needle, and so it will be known when it has all been removed.

The makers also supply a small spring balance attachment for testing the breaking strength of single threads. This balance is arranged to be hung from the long rod, shown in fig. 201, which can be fixed vertically. When the thread breaks, a catch prevents the spring from shooting back until the reading has been taken. Such a test as

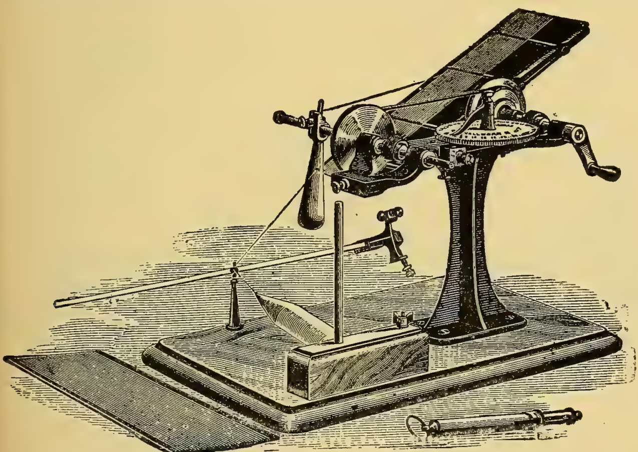


FIG. 202.—YARN TESTER. SHOWING HOW TO TAKE SAMPLES FOR QUALITY.

this will show where the weak places of the yarn are (if there are any), though of course to get the average strength a number of tests of single threads must be made to the average taken, or resort may be had to the ordinary yarn tester. An additional attachment for testing the strength of eighty threads at once is provided, which seems to be very efficient. It would be well if more attention were paid to tests of single threads, as this is the true way to find out the imperfections. To test eighty threads

at once is very well, but it tells absolutely nothing as to the variations of strength in each particular length of thread; and the sooner this is recognized the sooner the imperfections will be removed. In actual practical work the strain comes upon the single thread, and never upon eighty conjointly, and it will break at the weakest place.

In the manufacture of some of the better classes of cotton goods, especially those designed for white finishes, it is highly desirable to have an accurate and ready means of testing the amount of twist in single yarns as well as twofolds. For this purpose the tester illustrated in fig. 203

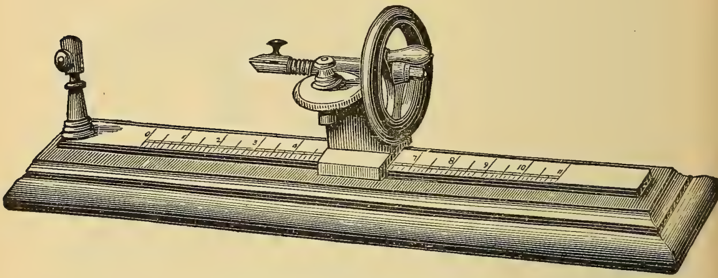


FIG. 203.—TWIST TESTER.

is a useful instrument. As will be seen, it consists of a base with measurements upon it. At the left is a fixed vertical standard carrying a clip. The one on the right is a movable standard with a small horizontal spindle carrying a similar clip to that just mentioned. This spindle has also a worm upon it, gearing into the bevelled edge of an indicator plate, which registers the number of turns taken out of the yarn. It is operated by the hand-wheel.

The ordinary method of testing the counts of yarn by wrapping is, however, very defective, and ought never to be relied upon alone. As will be obvious, to wrap a few leas from a few cops from each skip of a delivery of yarn, even when this is done regularly, which is far from being

always the case, is practically no test at all; the inference being purely an assumption when the conclusion is drawn that all the remainder of the yarn is the same. There are numerous ways in which errors, carelessness, wilful mischief, and even fraud, might vitiate the result. Suppose that slivers of different hanks get mixed in the drawing frame, or drawings, slubbings, or rovings, in the subsequent processes by which serious irregularities would be introduced; the test by wrapping would reach none of these in an effectual manner. As previously stated, in the spinning process it is now customary to spin yarns one to two hanks finer than the nominal counts, and to condition or reduce the hank to the proper point by damping. When the wrapping is done before the yarn is tested for damp, the result is thoroughly incorrect. Formerly the practice was to spin the yarn one to two hanks below nominal counts, and as much further as manufacturers could be induced to accept without demanding allowances. In order to prevent discovery of this, in some flagrant instances, the change wheels have been altered, and the top of the cops for a lea or two have been spun correctly. No imputation is made that such practices now exist; indeed, it is highly improbable that they do.

The only satisfactory way of ascertaining the counts of yarn is to test the bulk, and this can only be done by calculation. It can be done perfectly in the second process of manufacturing—that of warping. In the instances where ball warping is still practised, it is only necessary to work out by calculation what the weight of a warp should be; then to weigh the warps produced, and after making a very slight allowance for loss in the friction of winding and stretch in warping, the divergence between the calculated and the actual weight will show how much and in what direction the yarn is wrong in counts. In the much more common method, which is almost universal throughout the great weaving districts of East Lancashire—that of beam warping—all the empty beams

should be carefully weighed, and the weight painted upon the outside of the flanges. Calculations should then be made of the weights of the counts of yarns in use for the different numbers of ends ordinarily worked for three, four, or five wraps, as the case may be. All the warpers' full beams should then be weighed, the tare of the empty beam deducted, and the result compared with the calculated weight. This, as before, will show any departure in bulk from the counts. This method possesses the further advantage of getting a true test of the counts, even in the case where damping may have been suspected, as in the comparatively warm dry air of the winding and warping rooms all excessive moisture will have been evaporated. Of course it will not serve as a test for dampness.

Where the above practice is adopted and the results correctly recorded, it will be of great assistance in the production of uniform weights of cloth in the weaving shed, because in making up a set of back beams for the sizeing frame, uniform aggregate weights can be made by sorting the beams. This will eliminate one important source of irregularity, because when various marks of yarn are purchased by the manufacturer and worked without due care, it is no infrequent occurrence for sets of back beams for the sizeing-frame to vary in weight from 10 to 20 lbs., which variation is considerably increased by the process of sizeing. Hence it follows that in the weaving-shed all attempts to keep uniform weights of cloth by means of using different counts of weft are so frequently conspicuous failures. The plan stated here, if carefully followed, will give uniformly correct weights to the weavers' beams continuously, or at least with such slight variations as to be inappreciable in the cloth.

Testing Yarns for Strength.—It only now remains to give a brief description of testing yarns for strength. This is often judged by hand with great accuracy by experienced persons. The test is performed by taking a cop of twist in the left hand, drawing a length of the yarn from it

with the right, pulling it tight and then carefully observing its amount of elasticity and of force required to break it. This is repeated a number of times from the same cop in order to discover whether its strength is uniform or not. Several cops should be tested in this manner to ascertain if the threads are uniform with one another. This method at the same time can be used for inspecting the yarn as to its evenness. A glance thrown along its line, especially when holding it against a dark background, will show very easily whether there are thick and thin places alternating, or occasional thick or thin places alone. When the eye cannot detect any of these faults, the thread should be allowed to hang slack in a curve. In this state should it run into a kink, the thinnest and weakest place will be found there, as will be seen on stretching it again and pulling it till it breaks, which it nearly always will do at the point where it ran into a kink. In all uneven yarns the thick portions are the least twisted, and when very uneven these will be found to have very little twist at all in them, so little indeed that they form "soft" places at which the thread will not break with a snap, but the fibres will at that point come apart gliding over one another. This is owing to their imperfect union and compression, the twist or twine which should have accomplished this having run into the thinner portions of the thread. On the other hand if thin places be present in the yarn it will be found that they have more than their proper amount of twist. These will be hard and inelastic, and having fewer fibres in them than the proper quantity they will break with a much less strength of pull than they ought to do. Uneven yarn that shows thick and thin places, or soft and hard twisted ones, should always be avoided, especially for use as warps. The faults manifested in the examination of the cop as described will be accented in the process of actual work. The person who is entrusted with the duty of buying yarns should make a careful study of this method of testing because it needs no mechanical

aids to perform it, and enables him wherever he be to apply it to any samples submitted to him; and to very accurately decide whether or not they will be suitable for his requirements.

This method of examination is also an excellent one for ascertaining other defects in yarn. It very clearly shows the presence of "neps," which are very detrimental. These are fibres of cotton that have been caught between two surfaces of moving parts of the machinery in one of the preparatory processes of spinning or in the ginning process before them, owing to bad setting or subsequent derangement. Fibres thus caught are nipped and rolled up into little pellets, like grains of sand in size, and cannot afterwards be extracted. When the material comes to be spun, these nips or "neps," as they are corruptly called, are thrown to the surface of the thread, and are easily visible to the naked eye, or to a sensitive touch when the fingers are drawn over a length of the thread. Their presence greatly deteriorates the quality of the cloth in which they enter, because then they all come to the surface, and when the hand is passed over the surface of a cloth where they are present, it will be found to be remarkably rough. "Neppy" yarns ought to be carefully avoided.

The hand testing of yarns is also the best method for discovering other serious faults in them. Nothing enables a user of yarn to discover the character of a fault better than the hand test. For instance, when the cotton used is irregular in staple or length of fibre, short and long fibres entering into the composition of the yarns, the fact is easily detected by the fault which results. It is impossible to set the drawing rollers in the mule or spinning machine to properly work two lengths at the same time, for if they were set to work the long lengths, the short ones would be thrown out and far too much waste would be the result. If they were set to work the short lengths, less waste would be made, but another serious fault would arise. Such long fibres as were not broken would be worked

up at a slack tension with the short fibres at a proper one, and thus what is termed "corkscrewing" would take place. When this yarn came to be tested in the hand, the person testing it would find that instead of breaking with one sharp snap, it would make two little cracks in succession; or several little cracks in succession would be heard from different parts of the yarn before complete breakage occurred. These are termed "crackers," and indicate that the short fibres at proper tension where they are found side by side with long fibres at a slack tension have been broken, and that the thread requires a second or continuing pull to break the slack long fibres. Yarn of this kind is very poor, and will cause a good deal of trouble, and make bad cloth because of its weakness. This weakness arises from the fact that its strength lies in two small units, easily broken separately, instead of one larger unit giving the maximum of strength through perfect union.

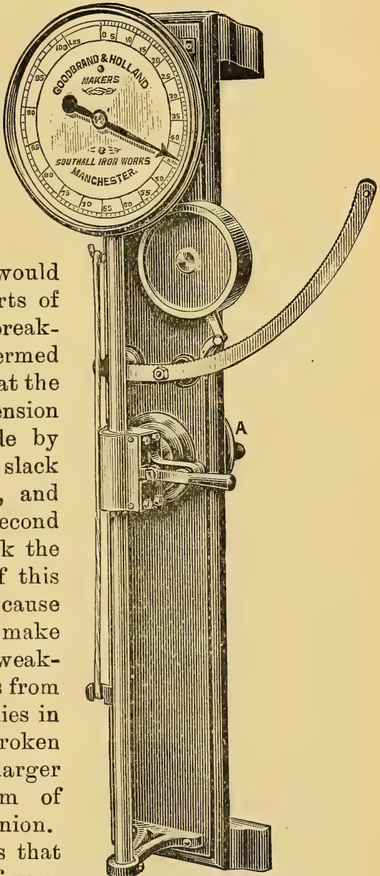


FIG. 204.—YARN STRENGTH TESTER.

It will be seen from this that we esteem the hand test of yarn very highly.

There is, however, a mechanical tester of the strength of yarn that may be resorted to

if desired. This consists of a machine composed of a wheel, worm and screw, a fixed and movable hook for the reception of the lea, and an indicator plate with index finger. When the lea is put upon the hooks, the bottom hook is wound down by the hand-wheel, A, adapted also for power, and as the strain upon the yarn increases it is registered by the index finger upon the plate. Immediately breakage occurs the pointer ceases to rise, and remains fixed at the highest position attained, which shows the weight in lbs. at which it has broken. This system gives the experimenter the average strength of 120 threads which are contained in the lea. It is a useful guide for rough approximations to the quality of yarns, but as in the processes of manufacture they are never subjected to such aggregate tests it is not a reliable one. It is shown in fig. 204.

It should be noted that the only true test of strength quality is that of a single thread, as it is to the units that the strain of actual work is applied, and this can only be effectively applied in actual work. It will thus be obvious that every new yarn should be carefully watched until it has established its reliability.

Conditioning of Yarns.—In all cases a yarn receipt-book should be kept, in which entries should be made of all parcels of yarn coming to hand. It should possess columns for the entry of the mark of the spinning, the gross, tare, and net weights of each package, the date when received into stock, and the nominal and actual counts. The store-room should be cool and dry, but not excessively so, as this would not improve the quality of the yarn. When the yarn is taken out of store for use it ought to be weighed again, in order to ascertain how much weight may have been lost by the evaporation of moisture. The store-room may thus usefully be made a conditioning-room. The quantity of water cotton yarns naturally contain is about 8½ per cent., this differing according to the hygrometric condition of the atmosphere. Any excess of moisture over this average should be claimed for, and, if not allowed, the spinning in which it occurs ought to be avoided.

CHAPTER XIII.

THE PROCESSES OF MANUFACTURING.

Definitions: Winding; Warping; Sizeing; Drawing; Weaving.—Peculiar system of paying winders; rates of wages.—Details of work; careful supervision required.—Winding weft yarns on pirns; pirn machines, *illustrated*.—Multiple yarn winding.—Proportion of winding spindles for looms.—Warping; points to be regarded; the weighing of beams.—Proportion of machines for looms.—Sizeing; its great importance; ball-warp sizeing; cylinder, and air-drying machines; important points; bad work; good work; proper drying; piece-marking; risks of loss accruing.—An improved piece-marker, *illustrated*.—The beam presser, *illustrated*; its advantages.—Drawing and twisting-in described.—Proper storage of beams, and healds and reeds.—Weaving; its chief essentials good weavers and good machinery.—The "gating" of new looms; requisites.—The tackler's bench.—Pickers, and how to season them.—Testing a new loom.—The shuttle and its importance.—The setting of the various parts of the loom.—The warp shed.—The pacing of the warp; the rope.—Simple and compound levers.—Hopwood's improved pacing motion.—Combined beam pike, ruffle, and flange.—The ordinary taking-up gear; details of a common dividend.—Pickles' and Sagar's gear; their advantages.—THE WAREHOUSE: the plating machine, *illustrated*.—Making-up.—Bundle pressing; improved bundle press, *illustrated*.—Delivery of the cloth.

AFTER the exposition already given of the development of the manufacturing processes from the primitive art of weaving, and of the series of machines employed therein, from the simplest form of the original handicraft loom to their present degree of comparative perfection, accompanied as it has been by a clear statement of the function of each machine and every part thereof, from which it is hoped that the reader will have gleaned a thorough comprehension of their separate and joint purposes, the description of the processes in which they are

employed, will not require to be dealt with in any elaborate manner. To recall the names and meaning of each of these to the mind of the reader, we subjoin a brief definition of each.

Manufacturing, as ordinarily understood, consists of five processes, as follows:

1st. "Winding."—This is the operation of transferring yarns—usually warp yarns—from the cop or hank, in which state they are mostly purchased, to bobbins, to prepare them for the next stage. Weft yarns are reeled preparatory to dyeing or bleaching.

2nd. "Warping."—In this stage a given number of bobbins—generally 300 to 500—are placed in a creel, and the threads are wound thence in parallel order upon a large beam, to the length of from 3,000 to 5,000 yards, or such other length as may be required. This is the plan pursued where the slasher sizeing machine is used. Where the old system of ball-sizeing is retained, but which is now becoming rare, the method is different. Sometimes, and increasingly so since the introduction of ring spinning, yarn is bought both upon the beam and in the form of "cheeses" or section warps.

3rd. "Sizeing."—This consists in immersing the warp yarns in a semi-fluid composition, consisting of water, flour, starch, and other ingredients. The object is, or ought to be, to lay down the projecting fibres and consolidate the threads to enable them the better to withstand the friction and strain incident to the subsequent process of weaving; but this in too many cases, owing to the severity of competition, has given place to a desire to increase the weight of the warp.

4th. "Drawing-in, looming, or twisting-in, the warp."—This is simply furnishing the warp with the healds or harness, to make it ready for the loom.

5th. "Weaving."—This is the chief process of the manufacturing division of the trade, and sometimes gives its name to the group. It is the art of interlacing threads

in such a manner as to make a web or texture. It is subdivided into branches—plain, twill, figure, and leno weaving. All these arise from the order in which the threads of the warp are opened to receive the weft or filling which composes the cross threads of the texture. The principles have already been fully described and expounded.

These are the principal processes; there are several subordinate or accessory ones. We may now deal with them a little more at length, and from the practical side, supplying at the same time such matter as the plan of this essay did not permit to be put forward previously.

Winders' Yarn.—It is a general custom in manufacturing establishments to weigh out given quantities of yarn to winders, the amount varying with the counts. These quantities are technically called "weighs," and the usual method is to pay 12*d.* per weigh, the wages of the winder being reckoned upon the number of the weighs she takes during the working week, which is generally reckoned from Wednesday to Wednesday, or Thursday to Thursday. It will be obvious that with the lowness of the counts, which represents shortness of length in the yarn, and consequently less time if not work in winding, the weight given out will be greater; and conversely as the counts rise, the weight to be worked for 1*s.* will be reduced. This principle always controls the weight of the "weigh." The "Blackburn Standard List," which until recently governed the rate of wages in the Blackburn and East Lancashire districts, gives the following as the weights of the various counts to be wound for 12*d.*:

Counts.	Lb. for 12*d.*	Counts.	Lb. for 12*d.*
18's	55	38's	32
20's	52	40's	31
22's	49	46's	27½
24's	45½	50's	26
26's	42½	60's	22
28's	40	70's	19
30's	38	80's	16½
32's	36	90's	14½
34's	34½	100's	13
36's	33½		

These figures have been incorporated into the new uniform list and are binding at the present time, but the prices are subject to a reduction of 10 per cent.

Winding.—In the winding-room of a mill there is not much that calls for remark, beyond pointing out that every precaution should be taken to prevent the making of an excessive amount of waste. This is the first stage of the manufacturing process, and the defects of the yarn are here first encountered. "Single," bad piecings, defectively cleaned, and roller-damaged yarn, may always be discovered here. The winding-room, therefore, requires the careful attention of the manager, but complaints must not be encouraged from the operatives, or it will be speedily found that yarn sufficiently good to suit them cannot be purchased. Waste in excess is frequently produced by careless operatives, and especially by learners skewering cops badly or entangling hanks. Too much severity, however, should not be exercised, as this will lead to waste being secretly carried away, or trampled under foot, which increases the loss. Attention should be directed to preventing the operatives making large knots in piecing up threads, as these are frequently the cause of breakages and defects in succeeding stages. Each winder, therefore, ought to chalk-mark or number her bobbins, so

that when bad work is found it can be traced to the responsible party.

The work in the winding-room should be carefully supervised by the winding master, as, though the operatives work by piece, the method used is an inversion of the ordinary one. The tale of their labour is the amount of yarn delivered to them to wind, and not the amount of work they have performed and have delivered to some one else. Thus there is nothing to prevent the winders taking "weighs" of yarn, and so making up a good week's wages, without having performed the work for which they receive them, except the strict supervision of the person in charge, whose duty it is to prevent this. If this is neglected there is risk that some of the winders may accumulate yarn upon and about their part of the machine and receive pay for it before they have wound it. Such accumulations are always a temptation to get rid of it by improper means, which should never be permitted.

In establishments in which different counts of yarn are used, care is required that these do not get mixed. The only way to avoid this is to have the bobbins painted different colours: one colour for each count, that these colours should not be departed from, and that they should not be allowed to get mixed in the working.

In the class of manufactories to which our remarks mainly apply, single yarn warps are almost invariably used, and therefore single yarn winding from the cop, or bobbin, or rewinding from the hank to the warper's bobbin is the only class of winding in use. Reeling for bleaching and dyeing purposes has been described in a preceding chapter.

In places where white or coloured yarns are used for wefts, the rewinding from the hank after bleaching or dyeing calls for a few remarks. The yarn in this case is wound upon pirn bobbins, which are coned at the top in order to allow the yarn to be drawn off at the top when the bobbin is placed in the shuttle. Of course pirn bobbins

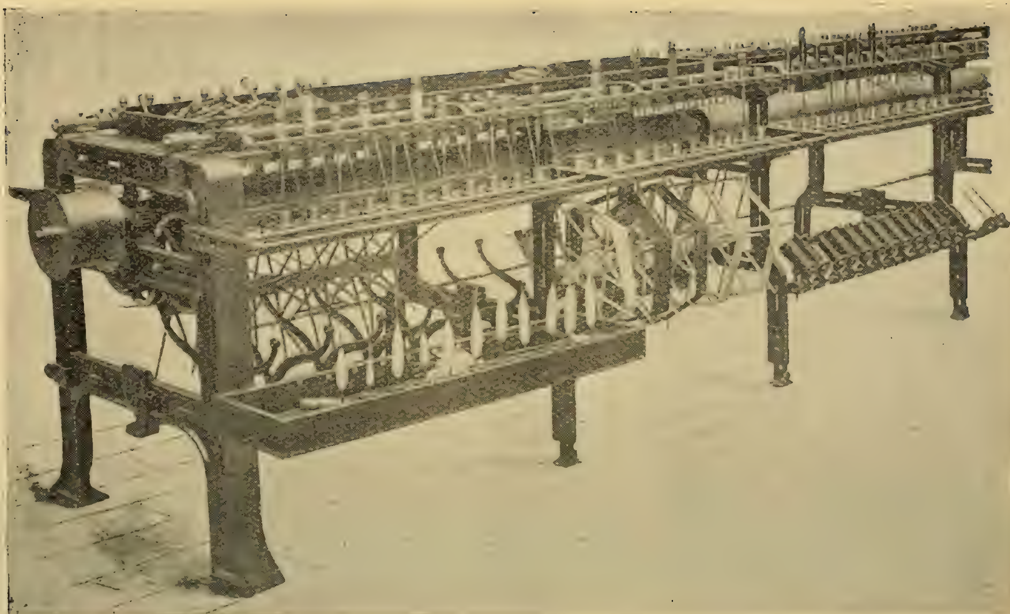


Fig. 205.—Cup Pirn Winding Machine, Mounted for Winding from Cops, Hanks, and Winders' Bobbins.

are made of the proper dimensions for that purpose, so that when filled with yarn they may not exceed the capacity of the shuttle to receive them. There are several types of pirn winding machines, of which we give illustrations. In fig. 205 is shown a cup machine equipped for winding pirns from cop yarn on the left-hand side of the machine; from hanks in the centre; and from winders bobbins on the right. These several methods are called into requisition in different establishments, but rarely all in one. The student must not erroneously conclude that all the different methods are usually combined in one machine, it being rare that they are arranged for more than one, or at most two. This frame of course would wind equally well from ring frame bobbins. It receives its distinctive name of a cup-winding machine, because it has a cup or hollow cone, the cone being point downwards, in which to receive the pirn for filling. This inverted cone practically constitutes a mould, in which during winding the cone of the pirn is formed. The details of the cup machine are fully shewn in figs. 206, 207 respectively, shewing end and side elevation, and method of gearing. Another type of pirn winder is termed the disc machine, so named from the use of a revolving disc plate with a bevelled edge, which, being placed in contact with the pirn bobbin, causes it to revolve and form a cone as before.

In other branches of the trade somewhat distant from that under review, twofold, threefold, or quadruple yarn winding is required. In these the winding process becomes more complex, and requires more care and skill to insure satisfactory results. Special machines, too, are called into requisition. These are much more intricate, and are fitted with ingenious arrangements to insure the winding of the two or more threads at absolutely uniform tensions, and also to instantly stop a bobbin when any single thread of a series being wound upon it breaks or becomes exhausted.

Where doubling or multiple yarn winding occurs it is

accompanied by the process of twisting, which is done on special machines constructed for the purpose. They are mostly of the ring-spinning machine type, but are without the drawing rollers. These, however, are too far away from the main topic of this essay to admit of further notice.

To return to single yarn winding: The number of winding spindles required for a shed of 500 looms will be from 600 to 900, according to the class of work upon

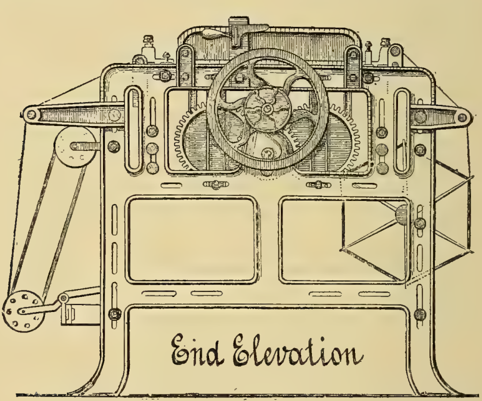


FIG. 206.—CUP WINDING MACHINE.

which it will be engaged. If the looms are making cloths containing from 15 to 20 picks per quarter inch, the smaller number will suffice. If, however, only from 6 to 15 picks are usually made the larger number will be necessary. The machines usually contain 300 spindles each, but are made to order of any size required. The speed of the spindles per minute is about 1200/1400 revolutions. The rate of the winding, however, varies all through the filling of a bobbin, being at its lowest when the winding surface is at its smallest diameter. The actual winding capacity of a machine will be obtained from the

revolutions of the spindle, and the mean diameter of the bobbin. From these particulars the manager will soon be able to calculate whether the capacity of the machines is equal or not to the requirements of the looms.

A strict watch should be kept upon the amount of waste produced in this department. To ascertain the percentages, the waste of the week should be carefully bagged in bags of which the tare weight has been taken. The total weight should then be ascertained. To this two

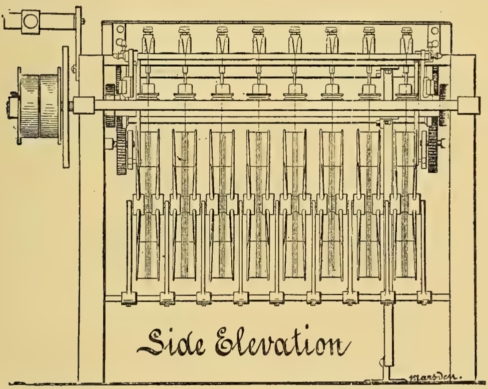


FIG. 207.—CUP WINDING MACHINE.

ciphers should be added, and this sum used for a dividend, the division being the weight of yarn weighed out to the winders during the same period. This will show whether the yarn is unduly wasteful or not. Of course the production of waste from each winder must be carefully examined, and all tendency to make an excessive quantity be checked. Care should also be taken that bobbins are not overfilled, as this causes waste by the yarn slipping off the sides. The temptation to overfill is that full bobbins wind the yarn more rapidly than empty ones, or "pieces" as partly emptied bobbins are usually called.

These partly emptied bobbins are what have been doffed from the creel of the warping machine. After having been once filled, bobbins are very rarely emptied, as it would seriously incommode the warper in "creeling" or refilling her machine with bobbins were this done.

The important point to be regarded in pirn machines is that they shall not glaze the yarn in the frictional contact that occurs, as this has a bad effect upon the appearance of the fabric which is woven from it.

Warping.—Warping is an important process as regards the economical management of a mill, as considerable waste may be made in it if care be not taken. Of late, however, owing to improvements in the warping-frames, much of this liability has been done away with. An important point to observe is that all the machines should, if possible, be of one make, in order that they may register exactly the same length of yarn, and thereby prevent waste with each set of beams when finished in the sizeing-frame. Should any inaccuracy or difference exist between the register of these machines, one beam will be finished before the remainder of the set, or will contain a quantity of yarn when the others are finished, in either case entailing the necessity of pulling all the yarn off the beams remaining after the first has been finished, and throwing it into the waste bag. It frequently happens that several pounds of yarn are lost in this manner which could easily be prevented if proper means were taken. There is, however, a still more important point to be observed in connection with warping, as it is in this process only that loss can be prevented. In an establishment which accepts small orders of cloth, and makes many varieties, great difficulty is often experienced in making the exact quantities. The consequence is that either too many or an insufficient number of pieces are made, but mostly the former. As merchants generally refuse to take those made over the order, a great quantity of odd lots accumulate on the hands of the manufacturer, which have to be sold at a con-

siderable sacrifice as "job lots." With the reduced profits that have been current for a long time, it will be obvious that the loss accruing upon these remnants of orders will considerably diminish the amount of profit upon the original one. With proper instructions and careful management there ought to be no difficulty in warping exactly the required length of yarn to suit any order; and the principal or the manager should probe every case of failure to the bottom, and see that those through whose neglect it occurred have the fact brought home to them, and be made to feel their responsibility.

The warping-machine beams should every one be carefully numbered and weighed, and the weights painted upon the flanges. A printed table of the weights of given numbers of "wraps" of different counts of yarns should be hung up in the room, and every full beam when doffed should be weighed, the weight chalked upon the flange, and compared with the calculated weight upon the table. This will show whether the yarns being purchased are true to their counts or not, and this will be the most effective check upon this important point. Where yarns are purchased from different mills it is highly necessary to see to this. It has also another important use: that of helping to keep the cloth of the right weight, as by this means sets of beams for the sizer can be made up of the right weight instead of, when no such care is taken, some sets running from 5 lb. to 20 lb. heavier than they should be, and others as much too light. These differences will be greatly increased after the sizeing process, the heavier yarn absorbing more size than it ought, and the lighter yarn less. The result will be great irregularity in the weight of the pieces of cloth, which no regulation by means of changing the counts of wefts will effectually correct. Trouble with the merchant will follow. All this may be avoided by care.

In a mill such as we are describing, containing 500 looms, five beaming machines, or one for every 100 looms

would be a proper complement. Should the work, however, be of lighter than average character, it would be well to have six or seven machines of a capacity of 500 ends each. A full description of the mechanism of this machine is given in a preceding chapter.

Sizeing.—This process in a manufacturing establishment is the most important of all. Though there are comparatively few operatives engaged in it yet more than half of the material consumed passes through their hands. Upon their efficiency and the careful performance of their duty depends to a great extent the success of the proprietors. The faults that either from neglect, inefficiency, or carelessness may arise in this department are very numerous and ought to be carefully guarded against, as their presence or absence may have much to do with rendering the fabrics produced either acceptible or otherwise in the market. It will be worth while to consider the process in brief detail, as if all is well managed here the subsequent operation of weaving is almost sure to be free from difficulty. We may here state that the preparation of the size—its materials, mixing, aging, storing, delivery to the machines—is such an important matter that it needs a brief chapter to itself, and will be found subsequently.

We exclude from notice the old system of ball-warp sizeing as a decaying one, and one which is generally carried on away from the manufacturing establishment, by people who make it a separate business.

The sizeing machines now generally used are of two kinds, the most common being the cylinder machine, so called from containing one or two cylinders, generally the latter. In this machine the yarn, after passing through the size, is carried round the surface of the steam-heated cylinder in order to dry it before it passes upon the loom beam. In the second form of the machine the yarn is dried either by hot or cold air. In this place it is not necessary to examine the respective merits of these two

forms of the sizeing machine, or detail the reasons which lead us, in common with the generality of the trade, to prefer the cylinder machine.

In the process of sizeing, the first point to be noted is that the yarn should not be subjected to strain at any part of the operation. The beams in the creel should turn or deliver the yarn to a very slight pull, and yet when the draught ceases should instantaneously stop, so that no slack should be made which would permit the yarn to run into "snarls" or kinks that might not be easily drawn out again. In order to prevent these it is usual to place a small roller across the yarn at a point near the size-box, which is fitted at each extremity into vertical-grooved brackets so that by its descent it can take down the slack, and so prevent their occurrence. Over the neck of each beam there should be a light pacing arrangement, consisting of a narrow leather band fixed at one end to a projection from the bottom of the frame, and thence carried over the neck, and having a small weight attached to the end. All the different working parts of the machine should be driven positively and not by the drag of the yarn upon them, and all the parts should be kept properly lubricated. Any strain is liable to destroy the elasticity of the yarn which ought to be carefully preserved to be available in the weaving process, in which the warp is usually subjected to a considerable strain. Yarn which is preserved from this strain in the sizeing process weaves much better, makes better cloth, gives a larger production, and owing to its greater freedom from faults commands a better price in the market. This is particularly the case when the fabric is intended for bleaching, printing, or dyeing.

One source of mischief in sizeing lies in over-drying. Cotton, which is a vegetable down, is covered by a natural gum which by excess of heat is liable to become hard, rendering the filament brittle. The same effect may spring from the baking of the size. The subsequent absorption of moisture from the atmosphere does not repair the injury,

as neither the wax covering of the filament nor the size dissolves again, or certainly not to a sufficient extent to enable the material to re-absorb moisture from the atmosphere sufficient to soften it for weaving properly.

One essential of good sizeing is uniformity. In an order for any particular cloth the warps should be throughout sized alike, whether the sizeing be done in one machine or a number. To accomplish this, after the size has been properly mixed, and has passed through all the successive stages of preparation, including boiling, that are deemed requisite, and is ready for use, it should be kept in a state of constant agitation so that it may be of uniform consistency when fed to the machine trough. The size in the latter must be kept at one level, so that the yarn in passing through it, may be always immersed to the same depth, and for the same length of time. This can only be maintained by an automatic feed tap for the sizeing trough. The size in the latter should be kept constantly boiling to prevent its heavier portions being deposited. After a stoppage of the machine for the day or meal hours, steam should be turned into the chamber, and the size be allowed to boil several minutes before the frame is re-started. The speed at which the machine is worked should also be as unvarying as circumstances will permit, and when working upon one order all the machines should run at the same rate.

Whatever be the system of sizeing employed, care should be taken to have the warp properly dried. When it is run upon the beam insufficiently dried there is great risk that before it can be woven through it may be damaged by mildew, sometimes to such an extent as to render it unfit for anything but waste. Where antiseptics are used this risk is diminished or obviated.

Much inconvenience and annoyance, and sometimes loss, arises from carelessness in marking the warp. It should always be seen that the marking-bowl is working properly and is provided with sufficient colouring matter. The mark should not be allowed to become too pale, because the

threads of the warp when passing through the healds being widely separated the mark becomes invisible and is frequently woven in without being noticed, and perhaps without an important heading, through the absence of which the piece is rejected. When a mark is too heavy, or runs into a long trail, it facilitates fraud by the weaver, who may draw the warp down as far as the trail extends or to the duplicate mark made by the offsetting of the proper mark, with greatly diminished risk of detection

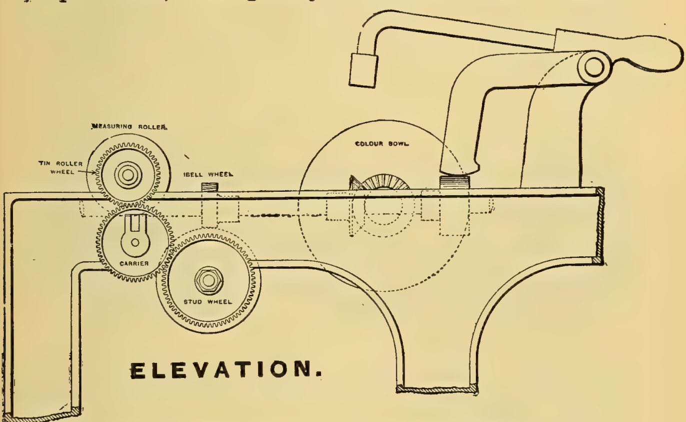


FIG. 208.—IMPROVED MARKING MOTION.

and so make the piece too short. A very excellent marking motion is the Hitchon patent made by Messrs. Howard and Bullough, Accrington. The following is a brief description with illustrations. The motion consists of three bowls geared together and operated by one driver, and constructed and arranged in such a manner as that when the centre one comes up a single mark shall be struck, this being intended to indicate the mid-length or middling mark, as the case may be. For heading or cutting-out marks, a double mark will be made by the two outside bowls being struck by the hammer. Along

the space left between these it is intended that the weaver should cut the cloth, thus separating one piece from another. The marks are made when the bowls present their flat sections to the stroke of the hammer, the rounded portions not being prominent enough to come into contact with the yarn when the hammer strikes. The hammer is con-

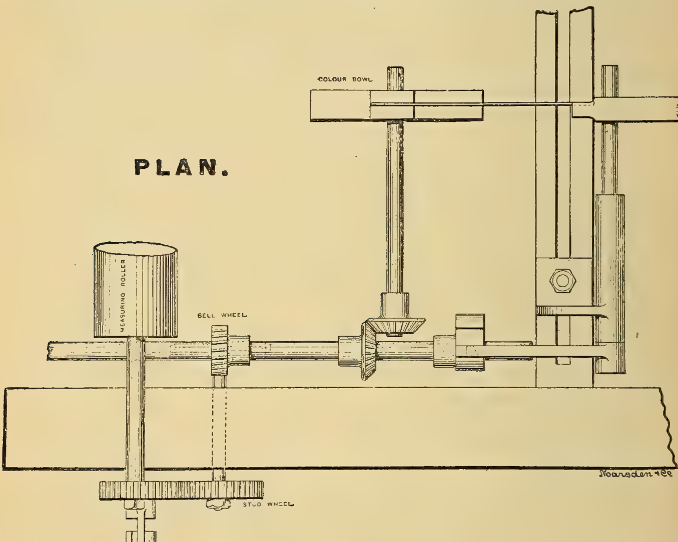


FIG. 209.—IMPROVED MARKING MOTION.

structed with three faces to meet the requirements of the change. These various points are illustrated in the accompanying elevation and plan, figs. 208, 209.

Should any of these points be neglected the result will be unsatisfactory; the warps will be too hard or too soft, too heavy or too light, leading to great difference in the weight, appearance, and feel of the cloth. So great is this difference at times that when the cloth is delivered to the merchant and examined by him, his suspicions are aroused that

the quality of the cloth contracted for is being tampered with, and deteriorated to his injury, when, in fact, the mischief springs only from carelessness and unskilfulness in the manufacture. But the dissatisfaction thus arising gives the merchant at home, or his customer abroad, a plausible excuse for heavily mulcting the maker in claims for abatements or in making rejections.

Every sizeing machine should have the beam presser as an attachment. This enables a greater length to be put upon the beam, which is economical. It also preserves the beam in better shape for the loom, and thus makes better cloth. Where the presser is not used, the beams in

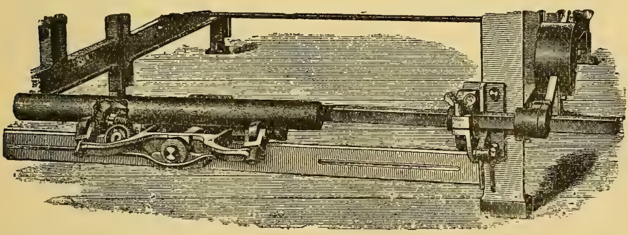


FIG. 210.—IMPROVED BEAM PRESSER.

being carried about frequently have their cylindrical form injured, by which the shedding of the warp in the loom is afterwards rendered defective, and inferior work produced. The presser consolidates the yarn as the successive layers are run upon the beam. The result is that much more length can be put upon them which is economical, whilst being made hard the beam preserves its shape better in handling. Our illustration shows an improved presser made by the firm just named. The presser consists of two lines of rollers, the one in front being made in two parts and tubular. This is mounted on a solid internal axle so as to be capable of expanding, the length over all being a little less than the width between

the flanges of the beam. This roller is mounted on anti-friction bowls carried in a suitable framing, but instead of the bowls having their axis parallel to that of the roller they are placed obliquely in swivel brackets which are capable of changing their position automatically. In whichever direction the peripheries of the bowls present themselves to the tubular rollers, the latter move towards or from the flanges. The back roller which is not an expanding one has its bearings formed so as to compel it to maintain a central position and thus to press the beam in the middle portion left when the front rollers have moved outwards. The general appearancc of the presser is shown in fig. 210.

Drawing and Twisting.—Drawing and twisting are such simple operations as to call for little more than a brief description.

Drawing, or drawing-in, is the name given to entering the warp into a set of healds which is done by an operative called a drawer-in, which may be a man or a woman. The process is as follows: The set of healds is suspended either from the roof or held up in a frame. Behind the healds the loom-beam with its warp is arranged parallel to the healds. The "drawer" takes his seat in front of the healds, and being provided with a single or double hook (the latter two hooks in one handle) for the healds, as the work may require, and a flat bone hook for the reed, he pushes the double hook first through two healds to the opposite side. There an assistant, a boy or girl, takes the first two threads from the warp and places them into the hooks, the drawer then drawing them first through the two healds, and next together into one dent, or split, as it should be called, of the reed. The child assistant is called the drawer's "reacher," because he "reaches" the threads to the hooks. This process is repeated until the whole warp is entered, when the task is completed, and the warp is ready for the loom.

A set of healds, however, if all goes right with them,

will weave from four to seven or eight warps. The second and subsequent warps, however, are not "drawn" in, but "twisted" in. This is a different way of effecting the same end. When the first warp is finished, instead of being cut out of the healds, the cutting is made through the end of the piece of cloth, thus leaving a "tab," which, on its side, holds all the threads of the finished warp in proper position. The "thrumbs" or waste end of the warp are next cut off on the opposite side, and either utilized by the weaver as thrumbs or passed to the waste-bag. The portion remaining in the healds is then tied up in several knots, so as to prevent any being drawn out. Thus the "set of healds and reed" are ready for the reception of another warp, or for storing away until required. In the former case they are suspended in a frame, and arranged opposite another weaver's beam containing a warp. The "twister-in," man or woman, then takes a seat between the beam and the healds, ties a given number of threads from the warp into a knot, then does the same with a similar number of those in the healds, and puts both sets of knotted threads into a peculiar shaped hook, called a twisting or looming hook. This done, he adjusts the tension evenly between the two sets, and with his left hand separates the nearest warp-thread from the bulk, and with his right hand the corresponding thread in the healds, with the same hand skilfully bringing the ends of the two threads together, he breaks them from their respective knots over the knife-edge of the hook, and deftly twists them together sufficiently firmly to enable them to be passed through the healds. In order to facilitate this process, both the warp and the yarn in the set of healds are furnished with a set of "lease" rods; or otherwise the warp has a lease "struck" by a comb. The new warp is thus entered or "twisted-in." This system is resorted to because it is more economical than repeated drawing-in. In the days of hand-loom weaving and the early days of power-loom weaving both these operations were done in

the loom, and hence were indifferently termed "looming" the warp, which might be either by drawing or twisting. The name of "loomer" is commonly given to the twister in the East Lancashire weaving districts to this day, but it is no longer strictly appropriate.

It is only needful to say further that the stock of filled beams should be so arranged that no damage should accrue to them before being taken to the looms. This is best insured by the use of the beam rack. This rack also admits of any beam of the lot being taken out without disturbing the others. The old method of making a pile upon the floor is objectionable, because by so doing the cylindrical form of the beam is crushed, and this tends to injure the shedding in the early stages of its weaving.

Healds and reeds should also be provided with racks in a dry room forming a store, where they should be assorted carefully, instead of, as is too common, being permitted to lie in heaps upon the floor, liable every moment to get entangled, broken, or otherwise injured. Before being put into store, reeds should be examined and repaired in order to be ready for use when required.

Weaving.—This is practically the final process of manufacturing, and has been sufficiently described in the preceding pages. The chief essentials are first—good machinery; and, second, a good class of weavers. Where either one or both of these are wanting it is difficult to attain good results. When delivered from the makers new looms formerly required careful adjustment by a person having a practical knowledge of weaving greater than the fitters in a machine shop. In the looms now made by our best makers, however, owing to the special methods of production and finishing, and the care exercised in each department, it is rendered difficult for the fitting to be otherwise than right, hence it is seldom necessary now to spend much time or labour in "gating." The best tackler or overlooker should be selected for "gating," as it is called. An economical consumption of power, oil,

strapping, etc., along with the production of a large quantity and a good quality of cloth greatly depend upon this being well performed.

The tackler intrusted with "gating" new looms will require his usual equipment of a bench, containing a few small drawers and a cupboard for his stores. His tools consist of a round and flat file or two, screw-keys, gouge, small drill, small and large hammer, chisel, pliers, and a strong vice fixed to the bench. The screw-keys are, we believe, commonly provided by the tackler for himself, and are his own property. The materials required for dressing or equipping the loom ready for the reception of the warp are a driving-strap, two pickers, two picking-bands, check-strap and ends, two stud-straps, and four heald-roller straps. These straps or bands are all of leather, and of their sorts should be of good quality. The pickers are made of animal hides, differently prepared from leather, not having been subjected to the tanning process. Of course a pair of shuttles must be supplied.

Pickers should consist of as few pieces of the material as possible, and be thoroughly well put together. The work they have to perform, that of throwing the shuttle from side to side, is very severe, and unless they are well made of good material, and well seasoned, they become an exceedingly costly article in their wear and tear. They are received from the makers in a hard, tough, dry condition, and should be stored in a thoroughly dry place before being put to season. They are seasoned by steeping in good oil, in which they should lie two or three weeks, or even months would be better. When removed from this bath they should be hung up, to drain away all superfluous oil. If this be neglected, the oil will fly out of them when at work and stain the yarn or the cloth.

When a new loom has thus been equipped, it is usual to let it run for a few hours without warp, but supplied with a reed and a shuttle. By doing this any defect is detected, and the parts settle down to their work without

risk of any damage to the warp or cloth. When this has gone on long enough to obviate such risk, the loom is supplied with a warp, given in charge of a weaver, and its course of commercial industry commences.

The shuttle is an important part of the loom furniture, which in consequence of its severe labour, quickly wears away on three of its surfaces—both sides and the bottom. When it has become worn on the bottom, the cavity for holding the cop becomes reduced, often to a point beyond which it ceases to be an economy to retain the shuttle in use. The cop protrudes on the bottom side, and its friction upon the warp causes frequent breakages of both the warp and its own thread, besides a great deal of waste by breaking the cop. The condition of the pins which retain the shuttle-peg in position, should be kept good, as this has much to do with preventing weft breakages making good work, and securing a large production. The pegs should be kept firm in their proper position in the centre of the cavity of the shuttle. When the grooved side of the shuttle is worn, it should be renewed, which can easily be done by means of a round file of proper dimensions. The best wood for making shuttles is boxwood, but the diminishing supply of this wood, and its advancing price, has compelled resort to other hard-textured woods. Compressed woods have also been successfully introduced for shuttle purposes.

Shuttle boxes should be carefully set for the reception of the shuttle, so that it will get home without being knocked from side to side, whereby it suffers serious damage, the wear becoming excessive. The setting of the picking cone and position of the bowl on the picking shaft has also much to do with securing a good pick, the points to be observed being that the pick should be of proper strength for the width of the loom, and in proper time for the shedding motion. The warp should be adjusted in the loom, so that a minimum of strain and friction shall fall upon it. In shedding, the heddles should not be tied to go

higher than will give a clear passage for the shuttle, nor lower than the inclined plane of the slay forming the shuttle race. In either case it will be subjected to unnecessary strain, which will cause breakages of the threads, impairing the quality of the cloth, and diminishing the production.

The letting-off or pacing of the warp is an important matter, for where this is defective the cloth produced cannot be good; it will be either slack, strained, or uneven. Many attempts have been made to perfect the pacing arrangement, but it is questionable whether it is not still open to further improvement, especially for the lighter classes of fabrics. For different purposes different forms are preferred by scientific and practical manufacturers. For the ordinary work of the cotton trade the rope or chain, and simple or compound levers, generally suffice. To insure that the chain should not cut into the necks of the beam, these should be covered with metal collars or ruffles as protectors. They also form a smooth surface, giving uniform friction around their circumference, thus greatly assisting to produce uniform cloth.

A deal of trouble sometimes arises from the pikes of the beam ends coming loose and working out. This is difficult to remedy completely, and it usually means that the beam to which it occurs has to be discarded. There has, however, just been invented a combined pike, ruffle, and flange, which promises where adopted to obviate most of the troubles arising from this matter.

The taking-up gear of a loom is a most important matter. The ordinary system consists of a train of gearing actuated by a small horizontal lever, which operates a pawl engaging with a rack wheel containing 50 teeth. On the stud of this is fixed a change pinion varying in the number of teeth with the requirement. This pinion gears into a carrier or stud wheel, having 120 teeth. On the boss of this wheel a pinion of twelve teeth is cast, which gears into the beam wheel fixed on the axis of the

taking-up beam which is operated by it. The circumference of this beam is 15 inches. The number of teeth in the driven wheels by this system are multiplied together, when the total thus obtained will form a dividend; for this a divisor will be obtained by multiplying the driving wheels, and the circumference of the taking-up beam in quarter inches. In this case it is simply the fixed pinion wheel of twelve teeth multiplied into the circumference of the roller 60 quarter inches. Put in another form it will stand thus:

$$\frac{\overset{\text{Rack wheel.}}{50} \times \overset{\text{Carrier wheel.}}{120} \times \overset{\text{Beam wheel.}}{75}}{\underset{\text{Pinion wheel}}{15} \times \underset{\text{Circumference of beam in }\frac{1}{4}\text{ in.}}{60}} = \begin{array}{rl} 500. & \\ 7{\cdot}5 & \text{add for con-} \\ \hline 507{\cdot}5 & \text{traction.} \end{array}$$

Thus we see that 500 is the calculated dividend from this system of gearing. When, however, the cloth is removed from the loom, and relieved from the tension under which it has been woven, a certain amount of shrinkage takes place, which experience has shown to be $1\frac{1}{2}$ per cent. This is compensated for by adding $1\frac{1}{2}$ per cent. to the theoretical dividend just obtained of $500 + 7{\cdot}5 = 507\frac{1}{2}$. The half is disregarded, and the 507 taken in common practice. When it is desired to make a cloth to contain a certain quantity of picks per quarter inch, the number of picks wanted is used as a divisor, in order to obtain the change wheel. Thus suppose a 15 pick shirting is required: then $15 \div 507 = 33 + 12$. Here we see the remainder, 12, is more than half the divisor, and in consequence a 34 change wheel would be adopted. On these systems of gearing it is very rare that net results arise, and it therefore becomes a question on which side the balance should fall. It hardly needs telling that self-interest inclines the scale in favour of the clothmaker, and that he prefers to take half a pick to giving a quarter.

To meet these difficulties several improved systems of gearing have been invented, and have come extensively into use. Two of these were invented in Burnley, namely, Pickles' and Sagar's. The former has come most into use, though the merits of the latter are as great if not greater. Pickles' gear has a swing pinion of 24 teeth additional to the above gearing, and also requires a second change wheel to get its results, which are very good.

Sagar's taking-up gearing was invented by the late Thomas Sagar, loom maker, Burnley, whose long illness and death prevented its merits becoming widely known. This system contains the same number of wheels as the ordinary one, but the functions of two of them are changed. The change wheel of the former becomes a permanent wheel of 24 teeth in this, and the carrier wheel is made into the change wheel. This will give quarter picks. The result is remarkable, for any pick or fraction of a pick can be accurately obtained in halfs, with twelve teeth, quarters as above, eighths with 48 teeth, or sixteenths with 96 teeth, and finer subdivisions if wanted, which of course would never be needed for practical work beyond quarters or eighths.

This system offers a great advantage in its power of dividing the pick into fractions, not only because it will prevent disputes as to cloths containing the proper number which can be given with the greatest accuracy, but also the same accuracy will guarantee the most uniform results in the finishing of cloths, preventing differences of appearances that under the old system beget suspicion and disputes as to whether or not an order has been honestly executed. The economy resulting is also worth consideration as a merit.

The Warehouse.—There is little call for the use of machinery in the warehouse of a cotton manufactory. Two machines, however, are now almost invariably found in them at the present time. These are the plating machine and the bundle press. The plating machine is to displace the

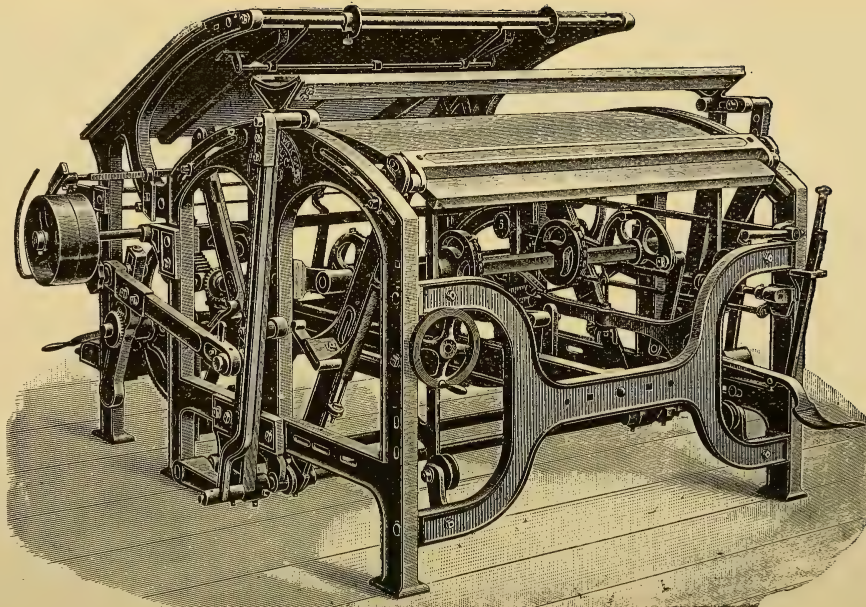


FIG. 211.—IMPROVED CLOTH PLATING MACHINE.

method of hooking by hand which is often objectionable because of the damage done to the cloth, caused by the perforations made by the hooks in the selvage. The plating machine, which is illustrated in fig. 211, as will be seen, consists of a strong iron frame. Inside the frame is a folding table, not flat, but constructed to form an arc of a large circle. This is arranged to move vertically up or down, and is guided by eight anti-friction bowls, two at each corner of the machine. Across the front and back, extending from one side of the frame to the other, is a grip rail or retaining bar, the under surface of which is clothed with strong card. The folding table is forced easily and constantly against the grip rails by means of pressure or balance springs, so that its top is always kept up to these rails when cloth is not intervening. The same influence holds the cloth in that position. The grip rails swivel on centres. They are actuated by a pulley or bowl carried on the side-arm, which, as the plaiter or folding-blade oscillates from side to side, comes into contact with inclined planes, and so alternately raises the rails. After the fold of cloth is laid, and the plater has passed away, the grip rails are pulled down by springs. The function of the plater is to lay the fabric upon the top of the table in folds in a straight and even manner. It is carried upon side-arms arranged outside the frame, and pivoted upon a bar extending across the middle of the frame at the bottom. The plater is a compound blade suitably curved for the purpose, and joined at each end, having a space left between its two edges. It is operated by means of a crank and arm of large sweep at the driving side, which is easily adjusted to make different lengths of a plate. In front of the machine there is usually a wooden box for the reception of the pieces of cloth. Taking the end of one of these the operative in charge passes it between the blades of the plater, secures it under the front retaining bar, and starts the machine. The plater then sweeps over the top of the table, carrying the cloth with it, which it presses

under the back retaining bar, by which it is held. Having completed its outward movement, it commences its return when its second blade comes into operation, and carries the cloth back to the other side, which it delivers to the front retaining bar, and thus forms a second leaf in the series of folds that are required for a piece. Owing to its peculiar mounting, the blades of the plater are swivelled to an appropriate position when approaching the retaining bars. The process is thus continued until the whole piece has gone through. As the folded piece increases in thickness the surface of the table is pressed downwards corresponding to the requirement until the piece is finished. The operative then, by means of a foot lever, depresses the table until the cloth upon it is clear of the retaining bars. At this position it is held by a detent, until the piece is withdrawn, and the end of another placed in the machine, when the work recommences.

The folded pieces from the hooking frame or the plating machine are thrown in a pile upon a large bench for the "maker up," a young man, who folds and assorts them according to their description, then ties them up in bundles of three, five, ten, or more pieces, as the case may be. If it be desirable that they should be pressed they are next carried to the cloth press, which may be a hand, steam, or hydraulic press. All of these are in use according to the requirements of the respective works. The press worked by hand is both slow and deficient in power; the steam press is quick in action, but for some work does not give pressure enough; the hydraulic press gives abundant pressure, but requires more time than is always available, so an improvement to meet the requirements of manufacturers has been invented.

In fig. 212, we illustrate an improved bundling press. In the arrangement of this press the table remains permanently in one position, and the pressure is brought upon the cloth by bringing down the top. This is accomplished by a small cross-shaft carrying the driving-pulleys.

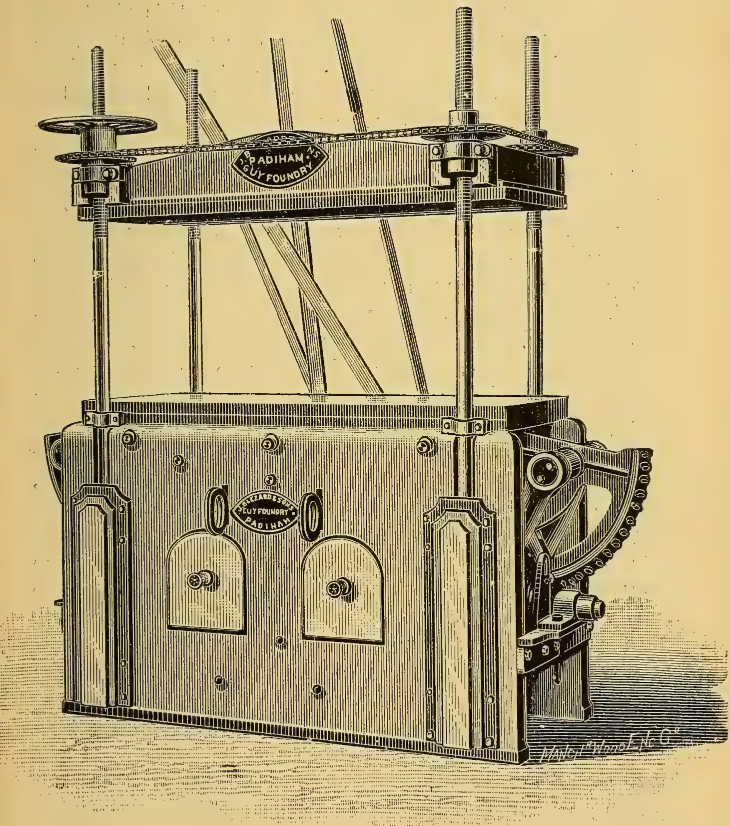


FIG. 212.—IMPROVED BUNDLING PRESS.

This shaft carries a level wheel gearing into a similar one on a longitudinal shaft. At the ends of this shaft are worms gearing into the quadrants, one of which is seen on the right of the illustration. The quadrants are right and left handed, so that they move outward and inward at the same time. Mounted upon the quadrants are connecting levers, so arranged that the action of the quadrants cause them to press upon arms attached to and extending inwards from the pillars, upon which the press top is mounted. The quadrant levers are so arranged as to bring very great pressure upon the pillars, by which the top is brought down very rapidly, compressing the bundles much more tightly, and very much more quickly, than can be done by any of the older types of presses. This is a great advantage, enabling the work to be got through much more quickly than before. To further accelerate the performance of the work there is a second pair of driving-pulleys, of half the diameter of the first. These are used for rapidly returning the top to its first position, when the pressing of a bundle has been completed. The larger ones are for bringing the top down upon the bundle. The handles for slipping the belts upon the pulleys are conveniently placed for the attendant. The top can be easily adjusted to the requirements of any size of bundle by means of the chain wheels upon the pillars.

There now only remains to despatch the cloth to the agents who may commercially handle it, or the merchant who may have purchased it. This is the stage at which the woven fabric usually passes out of the control and dealing of the manufacturer, and so naturally closes our journey with it through its various stages of production.

CHAPTER XIV.

Sizeing Materials and the Manufacture of Size.

The importance of size mixing.—The construction of cotton yarns.—The necessity and purposes of sizeing.—Organic and inorganic materials used in the composition of size.—The chemical composition of wheat flour.—Rice flour.—Maize flour.—Sago.—Corn starches.—Farina or potato starch.—The harshness of the sizeing materials, and the necessity of introducing softening matters; chloride of magnesium.—Heavy sizeing and mildew; legal responsibilities of the manufacturer.—Antiseptics; chloride of zinc.—Four prominent facts in sizeing.—Organic softening ingredients.—Tallow.—Palm oil.—Coco, castor, and olive oils.—Glycerine.—Irish moss.—Soaps; their composition, value, and uses.—Inorganic substances for weighting, deliquescent, and antiseptic purposes.—China clay; its origin, preparation, and chemical composition; qualities.—French chalk and terra alba.—Chemical salts: Epsom, Glauber's, and sulphate of baryta.—Deliquescents and their purpose.—Chloride of magnesium; its manufacture.—Care required in its use.—Chloride of zinc; value as an antiseptic.—Its chemical nature and manufacture.—Other antiseptics best avoided.—The blending of size; careful and thorough study of it wanted.—The progressive development of sizeing.—Mr. James Eastwood's inventions.—The mechanical size mixer and boiler of to-day.—Automatic drawing of the size.—Effectiveness and value of the mechanical size mixer.—Light, medium, and heavy sizeing, percentages of weight, and the cloths for which they are used.—Recipes for size mixings.—Weight in lb. of a gallon of chloride of magnesium, zinc, and water.—How to mix sizeing ingredients.—The steeping of flour.—Mixings for bleached and dyed yarns.—Sizeing of bleached and coloured yarns.—Dulling of colours by sizeing, and how to overcome it.—List of suitable colours for this purpose.—The proportions of water in size mixings.—How size mixings should "Twaddle."—The injection of steam weakens size.—Size mixing plant and sizeing machines should be placed near boiler.

IN the preceding pages a good deal has been said about sizeing, and the process and machinery employed in it has been fully described. But beyond incidental references, necessary to render clear the history of the develop-

ment of sizeing and sizeing machinery, nothing was said of modern size, its materials or methods of composition. The subject, however, was deemed to be of such importance that it was thought best to devote a brief chapter to the materials, composition, and treatment of modern sizes. As a preliminary to the perusal of this it would be best to re-peruse what has already been written upon the subject.

The warp yarns of nearly all classes of cotton fabrics require to be sized. This arises from the nature of the cotton down, and the mechanical structure of it, from which the yarns are made. These filaments are collapsed cylindrical tubes, having apparently corded edges. The end of the filament which was attached to the seed is open, showing its tubular structure; the opposite end tapers to a point, the tube closing and the filament becoming solid before the end is reached. This solid portion is more rigid and less manageable in spinning, it pierces the yarn, and projecting from the surface, gives it a downy appearance. These filaments in their different varieties range from about $\frac{1}{2}$ inch to $1\frac{1}{2}$ inches in length. In the construction of yarn they are placed by the different processes as nearly as possible in parallel order. Subsequently the mass is attenuated or reduced to such small dimensions that on the final draughting the number of filaments in a cross section will not exceed the quantity required to form the desired counts of yarn. The spinning then immediately takes places in which the filaments are twined together upon a common axis. This causes them to interlock so much as to cohere and form a continuous line conventionally termed a thread. To get as much consolidation as possible, warp yarns are twisted to a greater degree than those intended for weft or filling purposes.

To any one who has examined a filament of cotton, it will be obvious that such treatment as described cannot possibly make a solid thread, as there must be many cavities in it owing to the imperfect fitting of one filament

against another. It will be equally evident that, owing to the short length of each filament, and its solid point, which is less flexible than the collapsed tubular portion, the former will project from the surface of the yarn, giving it a hairy appearance. This is precisely what occurs. Used singly and without further preparation the yarn in this form would be quite unsuitable for warp purposes owing to the strain and friction to which it is subject in the process of weaving. The purpose and function of sizeing is to more perfectly consolidate and strengthen the yarn by filling the interstices between the filaments with a starchy composition which shall adhere to and bind the comparatively loose filaments together, so uniting them that they shall practically form one. This is the first purpose. The second is to lay all the projecting points upon the body of the thread so that they shall not be torn away by the friction, the thread be weakened, and the cloth impoverished in consequence. There is also a third object sought to be obtained in sizeing, which in a sense and to a certain extent is an illegitimate one, not being necessary to the manufacture of yarn into cloth, but arising from the severity of competition. This is to obtain an addition to its weight. A blend or composition of flour, starch, and other materials, technically termed size, is the means used to attain these several ends. It is the materials and manufacture of this according to modern methods that we propose to describe as briefly as possible. The selection of the materials, the blending of them in right proportions, the methods taken to ensure perfect amalgamation, and the subsequent application of the size in the best manner to the warp constitute the most important operations in the manufacturing division of the trade.

The materials used for the composition of sizes for manufacturing use may be grouped in two classes, organic and inorganic. The former mainly consist of wheat flour, rice flour, maize flour, farina, sago, and dextrine. The inorganic materials are mainly kaolin or china clay, chloride

of magnesium, and chloride of zinc. In addition there are a few other matters used in very small proportions for colouring or bleaching purposes; these are so small, however, that they hardly need be taken into estimation in this connection.

Wheat flour, though not always most abundantly present, or even present at all in some cases, may properly be termed the principal element in the manufacture of size, as generally compounded. It is simply wheat ground down into a very fine state, and having the bran or husk of the grain separated from it. There are a number of varieties of wheat, and different blends of these are made in order best to meet special requirements. This is the miller's task. Flour for sizeing purposes is, to some extent, a specialty and particular attention is therefore generally given to its manufacture. It should be white, sweet, free from any bad odour or acidity. Starch is the principal element in flour, amounting to about 66 or 67 per cent., gluten is there to about 11, and water to 16½ per cent. The remainder is made up of fats, sugar, gum, dextrin, and mineral matter in diminishing proportions. These proportions vary somewhat according to circumstances. The starch and the gluten are the elements chiefly useful in sizeing. Gluten is a more powerfully adhesive body than the starch, but the latter is quite strong enough for the purpose, and to carry other ingredients of the size with it in any required proportion, so that it is not necessary to specially select flours having large percentages of gluten. Sizeing flour, when such is known to be its destination, is liable to adulteration, the adulterant being usually rice flour, though sometimes sulphate and carbonate of lime are resorted to. Should size, during the course of manufacture, not behave in the usual way, or in use not give the anticipated results, recourse should be at once had to the flour, which should be carefully examined and, if necessary, chemically tested. If either quantity or quality of the essential elements to make good size are not

present, the size will not do the work expected from it. This will result in bad work, annoyance, and loss.

Rice flour is the ground product of the grain named. It is the seed of the *Oryza sativa*. It differs considerably in its chemical composition from wheat flour. It has a crisper, harsher feel than the latter, and is easily distinguishable from it. It contains about 75 to 85 per cent. of starch, nearly 10 per cent. of water, and nearly 7 per cent. of nitrogenous substances, the balance being made up of fat, cellulose, grain, sugar, etc., in small proportions. Its adhesive property is not so strong as wheat flour, and it will not carry as much china clay through the healds and reed as the latter. With suitable softeners it forms a good light size for weaving purposes, but should not be used for weighting with.

Maize flour, otherwise Indian meal, is the ground fruit of the *Zea Mays* or Indian corn plant. It contains from 55 to 65 per cent. of starch, about 10 to 12 per cent. of nitrogenous matters, is rich in fats, having 11·10 per cent. The remainder is 14 per cent. of water and balance salts and ash. It does not favour mildew so much as wheat flour, but owing to its colour it is not much used as a sizeing ingredient. The starch from this plant, commonly known as Indian corn flour, is a good sizeing material.

Sago is a starch, generally miscalled flour amongst merchants and sizers owing to its being sold under that name. It is the pith of several varieties of palms, extracted, dried, ground to powder, mixed with water and strained through sieves. Washed and dried it forms a fine starch powder which is imported largely into this country under the commercial name of sago flour. It is used for sizeing the better and finer classes of cotton goods. Like rice starch, it soon becomes watery and loses its adhesive quality. It should not, therefore, be made in advance of immediate requirement.

The starches from the real grain flours are also used to some extent in sizeing. Wheat starch makes a strong,

stiff paste, which can carry a large amount of the less adhesive ingredients of the size. Rice starch is a fine stiffening article, but for several reasons only meets with a very little demand from the sizer; it is in much more request amongst bleachers and finishers. There are several other starches, but they are not known in the sizeing room, except one of them, and this is potato starch, which occupies such a prominent position that it is entitled to a more detailed description than any of the above.

Farina, or potato starch, is produced from that well-known tuber which is such a universal article of diet in the temperate climates of the world. The potato in its natural condition consists of about 74 per cent. of water, 20 of starch, 2·17 nitrogenous substances, 1·65 cellulose, 1·07 gum and sugar, ·10 fat or oily matter, and 1·01 ash. In manufacturing the starch, the tubers are rasped down to a pulp by mechanical appliances. This pulp is mashed with cold water, the whole being received into a trough where the starch granules being of heavier specific gravity than water, settle at the bottom. The water is then run off and the starch is then forced through fine sieves, leaving the cellulose behind. The moist starch next has the water extracted from it by a hydro-extractor, after which the drying is finished by laying it, placed upon linen cloths, upon bricks or slabs of gypsum, to dry. It is next placed in dry rooms with a temperature of about 60 degrees, where it yields up still more of its moisture. It is then reduced to the state in which it is offered as a mercantile article.

There are several other materials in the list of size components, but relatively they are of little importance. Those already described compose probably 95 per cent. of the whole of the materials used for the primary purpose of sizeing, namely, consolidating the filaments of the thread, laying upon the surface all the projecting points, and causing the mass to adhere closely and firmly together.

Early experience amongst weavers showed that the

flours, starches, and other materials used for sizeing nearly always resulted in leaving the sized yarn hard and comparatively inflexible, causing far too much breakage. This was one of the causes which led the weaver to seek damp and moist locations for his loom, and when these were not easily attainable, to create an artificially moistened atmosphere around him by placing water under his loom, either in the "treddle hole," or in dishes, so that the evaporating water rising under the extended sheet of his warp should give it the desired softness. Tallow, oils, soaps, etc., all softening ingredients, soon followed, each being more or less of an improvement, but all leaving a something wanting still to perfect the condition of the sized warp. There were three states of the weather in which the weaver found himself placed at considerable disadvantage as compared with average ones; these were: in the dry heats of summer; when dry east winds prevailed; and in the dry frosts of winter. In all these cases his warp yarn broke much more frequently than was desirable, deteriorating the quality and reducing the quantity of work he could get through, and at the same time demanding more attention and increasing his labour. All the trouble was caused by the abstraction of moisture from his warp. This he wanted to counteract, and in his quest for means to do it, amongst other things stumbled upon common salt, chloride of sodium, the affinity of which for moisture was universally known. The stroke of genius in this case was in discovering its suitability for, and its application as a warp softener. It was an advance. As time went on the sizeing process began to be used as a means of adulteration, and more powerful softeners were wanted. The chemist had now begun to take cognizance of the wants of the sizer, and he came forward with chloride of magnesium. Good again; this seemed to have perfectly solved the problem. Any amount of size could be put upon the warp, and it yet be maintained in a weavable condition.

As a result of this discovery "heavy sizeing" came into

vogue. In the manufacture of cotton cloths for export in the grey or natural state, the proportion of cotton speedily diminished, whilst that of flour, starch, and other sizeing ingredients increased. But a new difficulty arose: heavily sized goods, when they had been transported to the eastern markets, began to turn out in an unmerchantable condition; instead of fabrics, masses of brown, yellow, and decayed textures were unfolded that would not bear their own weight. The increased amount of nitrogenous matters put upon the warp had formed an excellent soil for the development of fungoid growths or mildew, and this had done the mischief. At first it was thought it was accidental, but its steady increase led to investigations, as merchants found that the exportation of grey goods to foreign markets was becoming far too risky and involved too much actual loss to be followed. At length one or two specially bad cases were taken into court, and claims brought against the manufacturers for heavy damages. The plaintiffs won the suits, it being laid down by the judges that a manufacturer was bound to deliver goods free from any latent defect that could not be discovered at the time the goods were received by the purchaser, and that he must be held responsible for damages resulting from its subsequent development. This settled the matter of mildew claims, and this ruling remains law to this day. The manufacturer had then to meet new and hitherto unknown risks.

Again the chemist was forthcoming to help him over the difficulty. It was discovered that chloride of zinc was a powerful antiseptic. Half-a-dozen other articles were also tried with success, but zinc proved itself so efficient that everything else has been abandoned, and now little is heard of mildew in grey cloth from any quarter of the world.

This brief sketch brings four facts prominently into view: first, that sizeing is for the purpose of consolidating and strengthening the yarn that is subjected to the process; second, that tallows, oils, and waxes, as softening anti-

frictional ingredients, were required for keeping the yarn supple, and diminishing the friction of its passage through the healds and reed; third, that deliquescent salts are required to retain the natural moisture in the cotton fibre under varying atmospheric conditions, and if possible to attract more; fourth, that the before-mentioned materials are used as the vehicle for carrying others called weighting ingredients, introduced to improve the appearance of the fabric, and reduce the cost of production.

The softening ingredients, which now call for brief notice, with few exceptions range themselves under the head of organic materials. These are animal fats; palm, coco, castor, olive, and other vegetable oils.

Tallow is the fat of animals, and chemically consists of about seventy-five parts stearine, a hard, solid fat, and twenty-five of olein, an oil. It is extracted from the animal tissues mainly by heat, the process being termed rendering. The skin and tissues next have all the fat pressed from them. The latter is then clarified by being remelted in water, the clear fat rising to the surface, and the impurities sinking in it. The fat drawn off is the tallow of commerce. Russian tallow is the best for sizeing purposes, as it is harder than most other sorts, combines readily with the components of the size, and when on the warp holds them with more tenacity.

Palm oil is obtained from the fruit of a palm-tree indigenous to west tropical Africa, whence it has been introduced to the West Indies. It is one of the most valuable exports of the West Coast of Africa. The oil has the consistence of butter, is yellow in colour, mild in flavour, and has an odour of violets. It easily becomes rancid. Its colour unfits it for use in sizeing until it has been bleached. But as a bleached oil it is used as a softener, mostly in connection with sago sizeing.

Coco, castor, and olive oils are all well known vegetable oils, but though sometimes used in sizeing, are not of such importance as to require description.

Glycerine is a sweet syrup derived from fats and oils, both vegetable and animal. It is a cheap and valuable softening article, highly suitable for sizeing purposes, on account of its hygroscopic properties by which it will retain China clay upon the warp when the fats and oils would drop it. Care must be taken not to use it in excess, or the cloth will have a tendency to become damp to the feel.

Irish moss is an edible marine algæ, rich in mucilage, and sometimes used as a softener for other ingredients of size.

Paraffin is used in sizeing cotton goods not intended to be bleached, dyed, or printed. It is unfit for cloths intended to undergo these processes, as it cannot be scoured out by the usual agencies, and so practically forms a resist against either a bleach, dye, or print. Manufacturers who use this article in their sizeing process should be careful to ascertain the subsequently intended treatment of their goods, and if for the above purposes should suspend its use whilst such orders are passing through the sizeing-room, in order to avoid complaints, annoyance, or claims for damages.

Soaps of one kind or another very frequently form an important element in the composition of size. They are manufactured from animal and vegetable fats and oils, which are combined with alkalies. They vary greatly in real value to the sizer, as they can be made to carry large percentages of water. This of course is of no use, and ought not to be paid for, as it can be added without cost from other sources. What should be looked for in sizing soap is as large a percentage as can be obtained of the fats and alkalies in their combined form. Good soap is valuable in pure sizeing from fermented flour, the alkali neutralizing the acid it may contain developed from the fermenting process. It also dissolves the fats, and insures their more perfect blending with the other ingredients. The cloth made with it is soft and pleasant to the feel. Messrs.

Davis, Dreyfus, and Holland, in their well-known work upon "Sizeing and Mildew in Cotton Goods," give this caution, however, regarding the use of soaps:

"Soaps must not be used in sizeing if salts of the alkaline earths are present, since the fatty acids of the former produce insoluble combinations with them, which not only render both the soap and mineral salt of no avail, but the size becomes lumpy and filled with clots."

This about exhausts all that need be said regarding the organic materials employed for softening the other ingredients of size.

The next and last division comprehends nearly all the inorganic or mineral substances which are introduced for weighting, deliquescent, and antiseptic purposes.

China clay or kaolin is by far the most extensively used of all ingredients for giving weight and body to sized yarns. It is a natural production of Cornwall, where extensive beds of it are found at St. Austell's Bay. It is simply disintegrated felspar, and is obtained by directing a stream of water against the deposit, and separating the kaolin from the mica and grit by washing. The milky-looking stream as it runs off is directed into tanks in which the heavier portions and impurities which the stream may have brought away are deposited. The water still holding in suspension the finer matter, overflows from the first into a second series of tanks in which the suspended mineral is deposited. As these are filled in succession, the snow-white mud is drawn off into still lower tanks, where it condenses into a stiff paste. When this stage has been reached it is cut into blocks and exposed to the air, or is dried by artificial heat in suitable chambers. It is then ready for the market. Chemically regarded it consists of about 47·50 per cent. of silica; 38·50 per cent. alumina; and 12 per cent. water. The balance is made up of traces of other minerals.

There are many qualities of this article in the market. In purchasing it for sizeing purposes care should be taken

to select it as free as possible from imperfectly disintegrated portions of felspar, sand, and other impurities. The colour should also be as white as possible, neither yellow nor pinky.

French chalk, otherwise silicate of magnesia, and Terra Alba, or sulphate of lime, are sometimes mentioned in connection with sizeing, but that is not their chief sphere of utility; though occasionally used, they are better known in the bleaching and finishing processes.

Epsom salts, or sulphate of magnesia; heavy spar, or sulphate of baryta; and Glauber's salts, or sulphate of soda, are three sulphates that were more heard of as sizeing ingredients some years ago, when the art was passing through the experimental stage, than at present. They are seldom used now. The first and the last named are principally used in this connection for the stiffening after weaving of coloured goods such as Oxford and Harvard shirtings. They give a harsh feel to the goods if used alone, but this is neutralized by the introduction of the mucilage of Irish moss.

The inorganic materials we have described up to this point are mainly used for weighting purposes.

There remains the pure deliquescents, which though important, will only require a brief description. The function of these is to retain the moisture naturally present, and to attract more up to a given point from the atmosphere. They preserve the strength of the yarn by keeping it soft and flexible, and add to its weight by their attraction of moisture when there is plenty in the atmosphere.

The deliquescent salt most extensively used in sizeing is chloride of magnesium. It is commonly but erroneously called "antiseptic." It has, however, very little if any antiseptic power whatever, but was given the name on its introduction owing to a mistaken belief that it possessed it. It must not be relied upon in this respect. Chemically it is a combination of the metal magnesium with

chlorine gas. It is a bye product from the manufacture of chloride of potassium. The liquid producing it is evaporated to the point when crystalization commences. It is then stored in casks where this continues until the mass become solid. This is its mercantile form. It is used in Germany for the manufacture of artificial marble, in France for the making of magnesia cement, and in England for sizeing purposes. Its great value depends upon its high deliquescent property. If a small quantity be exposed to the atmosphere it will absorb moisture at such a rate as to soon become liquid. This shows that when used as a sizeing ingredient, it will in most states of weather preserve the yarn moist, soft and flexible, the best condition for weaving. Care should be taken to purchase it free from oxide of iron which tinges it yellow, and from the sulphates and chlorides of potassium and sodium, and especially chloride of calcium which would have detrimental results.

In compounding size when it is intended to use chloride of magnesium, soaps should be kept out of the mixture, as they would be decomposed and an insoluble compound be formed. It should not be used in goods that have to be hot calendered, as it is decomposed by heat and the acid set free would tender or destroy the cloth.

We now come to an equally, if not more, important element in the composition of size. This is chloride of zinc. The powerful antiseptic property of this salt has proved a boon to the cotton manufacturer. The law held him responsible for the development of mildew ravages after the goods had long left his possession and when he could no longer exercise control over their disposition or storage in places that would favour the origination of mischief from septic sources. The use of this material, however, in his size, practically sets him free from all risk, as introduced in the proportion of 8 per cent. of the size it completely destroys mildew spores or produces such an uncongenial soil as to render their development impos-

sible. Very little is now heard of mildew in cotton cloth.

Chloride of zinc is a compound of zinc and chlorine. There are various methods of manufacturing it. The usual one is by adding hydrochloric acid to metallic zinc. This dissolves the zinc, the result being the chloride of zinc. In purchasing this article for sizeing purposes, care should be taken to have it free from adulterations which are usually the chlorides of sodium and calcium. It should also be perfectly free from iron, which would discolour the cloth. A sample of very good chloride of zinc would give in analysis about 48 per cent. of actual chloride and 52 per cent. water. It should not contain more than minute traces of other matters.

There are a number of other articles sometimes spoken of as antiseptics, but the manufacturer will do well to avoid them and persistently avail himself of that which has been proved thoroughly efficacious.

With the foregoing brief description of the component materials of size we may now pass on to their blending. A blend is usually termed "a mixing." Its composition is dictated by the class of work for which it is intended to be used, and the more or less knowledge and judgment of the manufacturer or his manager. If an intelligent person connected with the business would undertake a careful and thorough study of this subject, it is our belief he would be well rewarded, as it is far from being exhausted. This certainly has never, to our knowledge, been done. It is a most important matter, and ought to be taken up in our best equipped technical schools by our practical weaving teachers who should work alongside and with chemical experts. There would then be something more reliable to guide one than the empirical conclusions that now serve the requirements of the trade.

In the early days of sizeing the materials were mixed by hand in pans, earthenware mugs, wooden tubs and sizeing troughs. As the materials seldom consisted of

more than a few pounds of flour with enough water to make a mixture of the consistency of cream, the task was simple and the labour not great.

In the second stage when sizeing developed into a separate business, mixing was still a manual operation, though conducted on a much larger scale. A number of hogsheads cut into two were adopted as holding more than the vessels previously in use. The custom of fermenting the flour magma, the blend of flour and water, was introduced, and these large tubs became convenient storage vessels. Their contents were systematically, at intervals, stirred up by a labourer who used a long pole. This task was not easy, and consequently was imperfectly performed. And the trade waited for an inventor to improve the method. In a while he came.

About 1856 Mr. James Eastwood, of Blackburn, invented and introduced to the trade the first mechanical size-mixing arrangement. It was a large churn-like tub, first conical then oval, fitted with a vertical shaft carrying arms or dashers by the revolution of which the size was agitated or mixed. This was driven by a horizontal shaft and bevel gearing fitted upon the top and connected by a strap with a shaft in the room. It was a great improvement upon the manual method.

But something else was required. The use of raw size, as the unboiled article is called, in the sizeing machine was the cause of a great deal of trouble, as it could neither be sufficiently boiled nor could any uniformity be preserved in the sizeing of the warps passed through it. To overcome this, a preliminary partial, or perfect boiling of the size was adopted, which was done by the injection of steam by means of a pipe into the mixer just described. This constituted another advance, and met with great favour from manufacturers. The sizeing tubs were, however, found to be inconveniently small, and a preference began to be expressed for a very perfect boil of the size before its introduction into the sizeing machine. In order

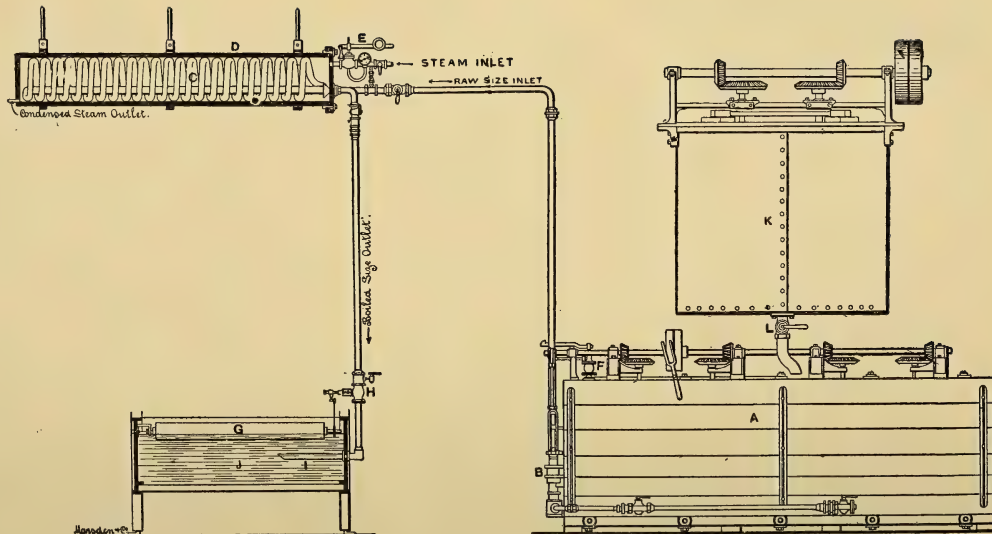


FIG. 213. MECHANICAL SIZE MIXER AND COIL BOILER.

to meet this requirement, the tub form was replaced by large square or oblong becks of great capacity fitted with several agitators. This gave an opportunity for obtaining more uniform results, as large mixings could be made at once, whilst it secured far more perfect fermentation where such was desired. But still the results were not everything that was desired. The boiling of large masses of size by the injection of steam meant a continuous introduction of additional water, derived from its condensation. How to keep this water out was the next problem to solve. Again Mr. Eastwood met the requirement of the case by devising a plan of forcing the size through a coiled copper tube, the coil being contained in a cast-iron tube forming a steam chamber which is kept heated with steam at a pressure of 12 lb., so as to boil the size as it passes through the coil. This with modifications and improvements in details is the system generally in use to-day.

The accompanying illustration, fig. 213, shows the details of the mechanical size mixer and boiler, as in use in most establishments to-day. In the beck, A, the size is mixed in the two compartments by means of the dashers, two in each, driven by the bevel gearing. It is divided into two equal compartments in order that one may be drawn upon whilst in the other a further supply is being prepared. There is a brass ram pump, B, connected with the two compartments in the manner shown, the piping being of copper, and the taps and fittings of brass, in order to prevent the rapid oxidation that would occur were these of iron. The size is drawn through these pipes from the cistern, A, and carried through the horizontal length of the tube to the left of the figure where it enters, and is forced, the coil being boiled on its passage, to the vertical outlet pipe, down which it descends to the size trough, J, of the sizeing machine. The coiled pipe is inserted into a cast-iron pipe, D, which forms a steam chamber. Into this steam is admitted, the pressure being regulated by the reducing valve and the steam gauge, E, so as to give

the requisite amount of boiling the size requires to suit the work in hand. The general working pressure is about 12 lb. per square inch. In order to regulate the supply automatically sent to and delivered by the coil, the pipe that conveys the size to the latter is provided with an overflow valve, F, which conveys any excess back to the compartment from which it is being drawn.

The flour, starch, or farina is prepared in the way shown in the beck, A, but the china clay, and the chemical ingredients need somewhat different treatment. They are therefore boiled together, but apart from the flour, etc., in the oval iron pan, K, which is fixed upon a stage above the beck, A. This pan is supplied with an open steam-pipe by which the contents are boiled. To secure perfect disintegration, the pan is furnished with two dashers which are driven in the same manner as the others. The mixture is drawn off into one or other of the compartments of the beck, A, according to requirement and at the proper time.

The size is also drawn from the coil automatically, according to the consumption upon the work. This is accomplished by means of the cylindrical copper float, G, which is connected with the feed tap, H, the combined action of the two regulating the quantity of size passing through the pipe, I, into the trough, J, exactly as it is taken up by the yarn passing through it.

This mechanical size mixer is a very effective machine. Like all the other machines we have had under consideration it has been of slow development, but now accomplishes everything that the manufacturer desires with a minimum of attention and a maximum of efficiency. It is not necessary to mix more size than the order in hand will take. This is only boiled and supplied to the sizeing machine exactly as it requires it. There is no fear of a short or excessive delivery. Every particle of the size must go through the boiling coil where it is uniformly boiled, it not being possible for any raw or half-boiled size

to get to the machine trough. It is installed in most of the weaving mills of Lancashire.

Sizeing varies according to the character of the cloths being manufactured. It may be roughly divided into four styles or kinds, namely, light, medium, heavy, and extra heavy.

Light sizeing includes all sizeing for weaving only; it is used for the better qualities of grey cottons, and for nearly all cloths that have to pass through subsequent processes, such as bleaching, dyeing, printing, and other methods of finishing. It would be a waste of material and labour, costing a considerable sum of money, to heavily size such fabrics as we have named, as in most cases the size would simply have to be washed out again. The percentage of size put upon the warp in light sizing ranges from about 10 to 25.

Medium sizeing is used in the manufacture of good and light classes of cloth usually exported in the unfinished or grey state, such as good shirtings, jaconets, mulls, and corresponding grades of bordered cloths. The percentage of size put upon the warp in these cases is from 25 to 50.

The next division is termed heavy sizeing, and the weight put into the warp is from 50 to 100 per cent. It is used in heavy, coarse fabrics, to give bulk and weight at little cost. Many of these goods are used for common linings, paddings, etc., and are as good for these purposes almost as if they were made of more costly material. The balance are the low qualities of grey cloths made for exportation. Enormous quantities are used for burial purposes in China and other eastern lands.

The last division is termed extra heavy, and includes all cases wherein the weight put upon the warp exceeds 100 per cent. This system is not in extensive use.

Of course in every case a more or less amount is rubbed off by the friction upon the warp in its passage through the healds and reed, and in the subsequent handling.

The amount is naturally greatest in the heaviest sized section.

We give a few recipes of size mixings to suit the varieties of cloths described. The mixings are large enough for average weaving establishments, as it is better to mix oftener than to run the risk of serious depreciation of the quality of the blend, owing to the origination and progress of chemical changes that might completely alter the nature of the mixing. The strength of size mixings is generally tested by the specific gravity which is ascertained by means of a hydrometer known by the name of Twaddell's hydrometer. This has a scale which is easily understood. When a mixing is thus tested, it is said to be "twaddelled." The degree indicated is given in figures with the letters Tw. following.

No. 1.—To give up to 25 per cent. on weight of warp :

Farina	400 lb.
Tallow	56 „
Wax	6 „

Chloride of zinc is unnecessary in the above.

No. 2.—The following is a good mixing for giving the same or a little more weight in cases where the yarns are lower in counts, and the cloth is wanted to have a bulky feel and to look full :

Wheat flour	600 lb.
China clay	200 „
Tallow.	15 „
Chloride of zinc . . .	30 „
Aniline blue	$\frac{1}{2}$ oz.

No. 3.—The following mixing will yield from 50 to 100 per cent. :

Wheat flour	500 lb.
China clay	360 ,,
Tallow	140 ,,
Chloride of zinc . . .	60 ,,
,, ,, magnesium . .	120 ,,
Aniline blue . . .	½ oz.

The above will give a good feel and a full look to the cloth. It will easily yield 100 per cent. if desired, or any intermediate weight down to 50 per cent., according to the specific gravity at which it is used.

No. 4.—The following is also a mixing for coarse yarns, and will give 100 to 120 per cent:

Wheat-flour	400 lb.
China clay	500 ,,
Tallow	250 ,,
Glycerine	50 ,,
Magnesium chloride . .	200 ,,
Zinc	200 ,,
Aniline blue . . .	1½ ozs.

In heavy and extra heavy sizeing, in order to be perfectly assured that mildew will not subsequently develop, mixings should always contain 10 per cent. of 102° Twaddell of pure zinc chloride to the gelatinous substances. When this proportion is present little fear need be entertained of bad results arising afterwards.

No. 5.—The following is a mixing to give about 50 per cent. on warp yarns up to about 34's:

Wheat-flower . . .	500 lb.
China clay	300 ,,
Tallow	100 ,,
Chloride of zinc, 102° Twaddell	56 ,,
,, magnesium . .	30 ,,
Aniline blue	½ oz.

No. 6.—The next will give 100 per cent.:

Wheat-flour	560 lb.
China clay	675 „
Tallow	140 „
Chloride of magnesium . .	80 „
„ zinc . . .	60 „
Aniline blue . . .	1½ ozs.

No. 7.—This is a mixing for "extra heavy" sizeing:

Wheat-flour	560 lb.
China clay	750 „
Tallow	150 „
Oleine	65 „
Chloride of magnesium . .	150 „
„ zinc . . .	120 „
Aniline blue	2 ozs.

No. 8.—In the following Farina is the principal ingredient:

Farina	700 lb.
Sago	250 „
Tallow	100 „

No. 9.—Another of similar description, which will give 25 per cent. weight on warp:

Farina	500 lb.
Tallow	20 „

The above recipes will probably meet all requirements.
Size mixings, however, are countless, as almost every sizer has some particular recipe of his own which he esteems above all others. Should any of the above be adopted, each operator will probably add some ingredient in which he has abundant, if not superabundant faith.

In the use of the chemical ingredients, and to facilitate

the change from gallons to pounds, or *vice versâ*, which will enable them to be measured, we give the following table:

1 gal. chloride of magnesium,	56° Tw.,	weighs	13 lb.
" " zinc,	96° Tw.	"	15 "
" pure water,		"	10 "

The China clay should always be well boiled. In making the mixing the zinc and magnesium chlorides are sometimes boiled with the China clay, but this is a mistaken procedure, and does no good whatever. They should always be added to the raw flour and water when they commence their action upon it. It should also be borne in mind that alkalis and chlorides are antagonistic or repellent bodies, and will not work together, and as the chlorides are indispensable, the alkalis, whether in the form of soda or soap, must be kept out.

Formerly flour was put to steep and ferment for from six to twelve weeks. This was for the purpose of breaking it up into the finest particles and to get rid of the most easily fermentable ingredients, and thus reduce the risk of mildew. But the general adoption of the new method of grinding by means of rollers, which reduces the flour to a much finer condition than the old system, a steeping of three weeks answers all requirements. The beck in which the dry flour is put to the water will store it until it is wanted. From this it is transferred by means of pipes and pumps to the final preparation cistern, which, as shown previously, has two compartments: one in use, and the other in preparation. From these, after the necessary treatment as previously described, the size is drawn and passed through the coiled boiler to the machine. When the weather becomes more than ordinarily dry, it may be desirable to add a little more chloride of magnesia which is the best ingredient for attracting and retaining moisture. The sizeing recipes we

have given above relate entirely to the sizeing of warps in the grey state.

The following mixings are in use in the sizeing of bleached and dyed yarns in the hank and ball warp form.

No. 1.

Wheat flour . . .	280 lb.
Soap	10 „
Tallow	10 „

This can be used at a strength of 14° to 16° Tw.

No. 2.

Sago flour	180 lb.
Water	36 gals.
Coconut oil	$2\frac{1}{4}$ lb.

No. 3.

Farina	70 lbs.
Sago	20 „
Soap	8 „
Tallow	2 „

To be boiled up with water to 15° Tw. These mixings give a light sizeing of a pure quality.

The following is a recipe for a heavy sizeing blend:

Wheat flour (fermented) .	230 lb.
China clay	440 „
Sago	50 „
Soap	50 „
Chloride of zinc . . .	50 „

Make up to a strength of about 42° Tw.

The following is another:

Wheat flour	280 lb.
China clay	560 ,,
Tallow	100 ,,
Chloride of magnesium . .	260 ,,
Chloride of zinc . . .	28 ,,

Make up with water to 45° Tw. If 8 lb. of soda be added, it is held to facilitate the mixing of the size, though we hold this to be doubtful.

In sizeing bleached or coloured warps a rather stronger size is used: that is, one Twaddling heavier.

Heavy sizeing often dulls the colours of dyed yarns making them look milky. It is desirable to avoid this, which can be done by adding to the mixing a little dye-stuff, the so-called direct or substantive dyes lending themselves best to this purpose. Of course, a colour appropriate to that of the yarns being sized must be used.

The following will be suitable:

For Pinks:	Erika or Titan pink 3 B.
,, Scarlets:	Diamine Scarlet 3 B, or
	Titan ,, C.
,, Dark Reds:	Titan red 6 B, or
	Benzo-purpurine 6 B.
,, Blues:	Titan blue 3 B.
	Benzo-azurine.
	Benzo-blue BX.
	Diamine blue 2 B.
,, Yellows:	Titan yellow R, or
	Oxyphenine.
,, Oranges:	Titan orange, or
	Congo ,, R.
,, Browns:	Cotton brown, or
	Diamine ,,

For Greens:	Diamine green B, or a mixture of a yellow and blue.
„ Blacks:	Diamine jet black S S, or Direct deep black T.

These dyes fix themselves readily upon the yarn and give fairly fast colours. They are particularly useful for this work.

In making blends of size, of course water is an indispensable element. There is no rule by which the quantity can be stated beyond this, that it may generally be added until the mixing becomes of the consistency of thick cream. It will then need thinning down to the state in which it will give the required weight upon the warp. The proper degree should be ascertained by the instrument usually termed "a Twaddle." Roughly speaking, for the low and medium counts of yarns, which are those usually sized from the lightest to the heaviest degree the following will give a guide:

	per cent.	per cent.	per cent.
Yarns, 16/36	25/50	50/100	100/200
Should Twaddle about .	15	25	40

Intermediate figures from these can easily be obtained. The best water to use for mixing purposes is that from condensed steam.

In dealing with size it is important to bear in mind that the injection of steam into it means the introduction of additional water, and consequencely a weakening of the mixing. If compensation be not made a considerable diminution of the percentage of size put upon the warp will probably ensue. Neither should it be forgotten that if the sizeing becks in which the size is boiled, or the sizeing machines served with steam for boiling in the trough

be located a considerable distance from the boilers, there will be a much greater condensation of steam, and, consequently, they will receive a much larger proportion of water than if they were near to the boilers serving them. As a matter of economy, therefore, the sizeing plant and machinery should be placed as near to the boilers from which they will be served with steam as possible.

CHAPTER XV.

HINTS ON MANAGEMENT.

A good practical or theoretical knowledge of the trade by principals a requirement of success.—Checks carelessness and promotes efficiency amongst subordinates.—Best locations and sites for weaving mills.—Temptations to indiscipline.—Managerial oversight.—Qualities of a good manager.—Foremen.—The winding master and his functions.—Winding.—Warping.—Uniform weights of sets of beams and how to get them.—The sizeing room and its supervision.—Details.—Tacklers and their duties.—Should possess technical knowledge.—A good tackler will get good weavers.—A good class of weavers a necessity.—Good discipline in the weaving shed conducive to success.—THE WAREHOUSE an important department.—The piece book and the "tally boards;" checking errors.—Cloth-looking; various methods.—Defective cloth.—The onerous duties and responsibilities of a cloth-looker; qualities of a good one; necessity of supporting his authority.—Hooking or plaiting and making-up.—Overworking the warehouse staff, bad policy; mill and Manchester cloth-lookers.—Disadvantages of buying poor yarns.—Isolated strikes.—Immoral conduct.—The Factory Acts.—Mill managers should be acquainted with them.—Why employers are prosecuted for the offences of operatives.—A means of defence.—Clause 87 of the Act of 1878.—The "Steaming Act."—Atmospheric humidity and its variations; its influence upon cotton weaving.—The suspension of water in the atmosphere at various temperatures.—Means of measuring it.—Humidity schedule of the Cotton Cloth Factories Act.—Care required to avoid penalties.

IN face of the competition and frequent depressions occurring in the cotton trade it is incumbent upon those engaged therein to conduct it with care and economy in order to assure success. This, however, can only be accomplished in the most perfect manner where the principal or principals are thoroughly conversant with the

practical details of the work of each department, which will enable them to trace the results of neglect, carelessness, or bad workmanship directly to those who are responsible. More than this is also required: the principal, or one of them where there are more than one, should be a good business man in order that he may take safe charge of the commercial portion. This is quite as important as the practical part, because incompetence in either division will often neutralize the best of skill in the other. It is only rarely, however, that these qualities are combined in one person, and even where this is the case it is impossible to bring all into full play. One portion of the duty must be delegated to a second person, whose interest, if he is not a partner, is necessarily less than that of the principal. A firm consisting of the partnership of two persons, one of whom has had a thorough practical training, and the other an equally good commercial education, offers the best combination for insuring success, assuming that other requisites, such as character, etc., are what they ought to be.

As, however, it is not always that a practical knowledge of the trade can be acquired by persons desirous of engaging in it, the best thing in these circumstances is to get a good theoretical acquaintance with the different departments, and the nature of the processes carried on in each. This will tend to promote efficiency, as it will enable a master to check the carelessness of servants who neglect their duty, presuming that no one will be able to find out the source of the mischief. It is doubly necessary in times like the present, when profits in most branches of manufacturing have been much reduced, that the most careful supervision should be exercised, and that the machinery should be put into the best condition its state will allow, in order that the least possible waste may be made and the best work brought out; in other words, that the highest quality may be produced at the least cost. In order to aid in a small degree those who have not had the advantage of a practical training, it is proposed in this

chapter to offer a few hints that may be found of use in the management of weaving establishments.

Weaving mills are best located in the weaving districts. In making election of a particular place, regard should be had to the class of goods it is intended to manufacture. When the locality has been decided upon, great care should be exercised in selecting the site, which should be amongst the best class of workpeople in the place, and in a neighbourhood which has few, or better still, no drink-selling places in close proximity. These very often prove a great difficulty in the management of a mill, and greater in a weaving than in a spinning mill, because of the larger number of people usually employed in the former. Amongst the three or four hundred people thus gathered together, it often happens that there will be a small percentage addicted to drinking. These will take advantage of every little accidental stoppage to resort to the drink-shop, from which it is almost impossible to drag them until they have rendered themselves unfit for work for that and, perhaps, several following days. Wanting these trifling chances of self-indulgence, they will frequently make others, and be found stopping away to indulge in their favourite vice; and the manager and overlookers will, perhaps, at a busy moment find a dozen or so of looms without weavers, when the fullest production from every one is required, in order that contracts may be completed in time. But this is not the only, and hardly the most serious evil, that results from this bad habit. Whenever the weavers in a shed can see looms standing for want of weavers to superintend them, discipline becomes relaxed; carelessness and idleness take the places of care and steady industry; and a worse quality of work, and less of it, is the consequence. It is absolutely requisite that any infractions of discipline of this kind should be punished by instant dismissal. The saying that "a sickly sheep will taint the flock" was never more true than in this connection. Unless the manager has to lose all control of the establishment, this

evil must be dealt with in the firmest and sternest manner. It is pleasing to believe, however, that it is a diminishing one.

In the event of the owners not taking charge of the internal management, it will be found desirable to appoint a manager. The oversight of a manager is a necessity in a cotton manufacturing establishment, and in some much more so than in others. The one making one or two standard fabrics from year end to year end needs comparatively little, whilst another, making it may be miscellaneous goods, will at times have from 20 to 200 sorts going at once, all of which must be looked after in every detail in order to prevent matters going wrong. Thus the one position involves a great deal more labour and responsibility than the other, and will require a manager with a great aptitude for dealing with details.

The first requisite for a good manager is a thorough mastery of details. It would be best that he should be practically conversant with the work of every process. This, however, is difficult to obtain. The next best thing is that he should have been trained for the post: that is, that he should have entered the mill and have undertaken a course of study of every process, with the view of acquiring as thorough a knowledge of the principles and best practice of each that should be possible by an intelligent young man in the course of two or three years. Besides making himself familiar with the details of each process, he should constantly carry in his mind, and be ready to put to himself the question: Can as good, or better, results of the process before him be attained more economically? Is there anything in the organization of this department that can be improved? A critical examination will result from the putting of these questions, and it will be astonishing how many weak spots can be found.

A student for a managership will go through his study of the processes all right, but will necessarily have to come

out imperfectly trained in one respect: he will not have been entrusted with the management of the workpeople. This he can only acquire in the actual work of his vocation. He may, however, whilst acquiring the preliminaries, keep his eyes observantly open to the doings of the workpeople and mentally note that which is right and wrong. He will thus train his observation in a valuable manner for the performance of his future duties, and will find the accomplishment almost invaluable when called upon to put it into practice.

A good manager will take care to obtain a good staff of foremen. These in a weaving firm will consist of sub-managers, if the firm is a large one having several mills, winding and warping masters who take charge of the winding and warping department; foreman sizer, where there are a number; foreman drawer, or twister, when the mill is large; tacklers, or tuners, as they are in some places called, who have charge of the weavers; and, lastly, the cloth-lookers.

The function of the winding master is to take the general supervision of the winding and warping room. He engages and dismisses the operatives; instructs them as to the counts of yarn they have to work; sees that the winding is done upon the proper colour of bobbins, and that these are not mixed; takes care that the winders mark their bobbins, for the purpose of subsequent identification if required; checks the making of excessive waste and the over filling of bobbins; sees that the workers are properly supplied with yarn without favour or partiality as to either quantity or quality; takes care that no undue accumulation of yarn is made upon any of the "sides" as the winders' portions of the machines are termed; and maintains strict discipline as to the proper attendance and general behaviour of the workers when at work. Preferably the winding master should be an elderly married man of high moral principle, even tempered, and very firm, as the good management of a large number of

females needs both skill, prudence, and great firmness. Other remarks equally suitable to this place will be found in the preceding chapter.

The warping or beaming, section of his charge, also requires care in the details of the work. The main requisite is to see that the proper number and lengths of back beams are made to complete the orders received by him. There is little or no trouble in doing this when standard cloths of one count of yarn are made from one year end to another. It is different, however, where every set of beams vary in either counts or lengths. It is then there is required the exercise of the greatest care to avoid waste, or loss and annoyance by spoiling the orders through deficiencies, or overmaking them and having job lots left.

It should be the winding master's duty to make his sets of beams for the sizer of uniform weight, and these as near as possible to the calculated weight required that with the addition of the size and the proper counts of weft in weaving will best give the contract weight of the cloth. If this be neglected here it cannot afterwards be remedied. It has already been told how this should be done, namely, by taring every empty beam, painting the weight on the flanges, weighing each full beam, chalking the weight above the tare and thus getting the net weight. Should these vary, the proper set weight should be got from an assortment that will make it up correctly. Light sets and heavy sets should never be made, as these defects will be exaggerated in the sizeing process, and all sorts of piece weights come from them. The gross, tare, and net weight of every set of back beams sent to the sizeing machine should be recorded, and preserved for reference in the event of the weights coming wrong from the looms. This will permit of accurate investigations being made into the quality of the yarn, and will reveal negligence in sizeing. Yarns differ in their power of absorbing size, especially owing to the variation of twist in them. A strongly

twisted yarn is necessarily more consolidated than one containing less twist. The first absorbs less size than the latter, though the counts may be the same. It is desirable to obtain yarns to work together that are uniform in their amount of twist. These points are worth a manager's careful attention.

The sizeing room on many accounts demands a large share of the attention of the foreman sizer, if there be one, or if not, of the manager. Upon the proper and continuous working of the sizeing machines depends the regular supply of warps for the looms. Care must therefore be taken that there is always a set of beams ready for the machine immediately the one in work is finished. Precedence must be given to the most urgent orders, so as to avoid the risk of complaints and cancellings of orders on account of non-fulfilment within the stipulated time. If the looms get filled up with orders that are not urgent they cannot conveniently be emptied in order to put in work that should have gone in first. The manager must therefore carefully measure the productive capacity of his looms upon and by his orders in hand, and on that basis give precedence in the sizeing room to the orders that will be required to be delivered first. This is a point that deserves his first attention.

With careful, steady, sober, and efficient men the sizeing room ought not to give the manager much trouble or care; but without such men it will give him a great deal. A drunken workman in this room may easily do a vast amount of injury, and inflict a large loss upon the employer. Such a man is best got rid of in order to avoid such contingencies. Every sizer should be instructed to report to the manager irregular or bad work that involves inferior work passing from him to the weaving shed, or that results in loss of yarn.

In other respects the sizeing room will not demand much further notice. The chief points to assure are a sufficient supply of steam for the proper boiling of the size

in the trough; and in the cylinders to thoroughly dry the yarn in its passage over them. The machines should be kept clean and well lubricated in their bearings, the measuring arrangements properly adjusted, correct change wheels used, and the beam presser kept in accurate working order. No loom beams should be put into the machine with loose or crooked flanges. In doffing the slow motion should always be used in order to prevent the baking of the size upon that portion of the warp upon the copper rollers. In lengthened stoppages the yarn should always be brought out of the size trough by raising the immersion roller, in order that no baking of the size may take place upon it. The rollers and the size trough should be kept perfectly clean, and no old size should be allowed to cake or accumulate upon any part. A manager should accustom himself to see at a glance when any of these things are neglected, and insist upon prompt attention to, and the maintenance of proper order in every case.

The next point of importance is the engagement of a good class of overlookers—tacklers or tuners as they are usually called—to take charge of the looms and the weavers. The function of the tackler is to keep the looms of which he has the oversight in good working order; to supply and "gate" new warps in them when the preceding ones have been woven through; to give the weavers all necessary information regarding weft, headings, middlings, or any other detail needed for the proper performance of the work. The tackler is charged with the oversight of a given number of looms, termed a set, the number varying in them according to the amount of supervision and attention the class of work may require from him. In the Burnley district of East Lancashire, where light printing cloths are made, a set may consist of about 120 looms, this being about the maximum number. In places where the looms become more and more complex in construction, and require more care, as in the manufacture of fancy fabrics, the number of looms in a set diminish until they

get down to about fifty or sixty, which will be about the minimum. Tacklers are paid by a commission upon the earnings of their weavers of so much in the £, and hence is termed poundage. This varies a little, according to the character of the work and the number of looms in a set. This system of payment ensures stricter supervision over and discipline amongst the weavers, and so is conducive to both quantity and quality of production, and consequently to the economical working of an establishment.

Tacklers are made from weavers. Of course they are always men, the nature of the work required being unsuitable in many respects for women. The position is both financially and socially a promotion from the post of weaver. The qualities required in a tackler are: a thorough knowledge of the principles and construction of looms, and of the weaves that can be executed upon them, especially of those of which he ventures to assume the oversight; mechanical ability, enabling him to see at a glance when, how, and at what point a loom has gone wrong, and to set it right again. He will need at times to instruct the less competent weavers in some one or other of the details of their art of which they may be ignorant; physical strength is a valuable quality, as it is required in carrying the heavy beams to the looms, and is occasionally useful in exigencies that may arise in connection with the maintenance of discipline; and, lastly, moral character, and skill in the management of workpeople, are also valuable traits in a good tackler. In order that a tackler may do the best both for himself and his employer he is generally entrusted with the power to engage and discharge the weavers over whom he is placed. It is therefore his ambition and interest to get the best set of weavers he can obtain.

But the main requisite in manufacturing, after the best machinery, is a good class of weavers. Without these, even good machinery and the best preparation will go for little. Rigid discipline is necessary to train operatives to

a good standard, and to keep them at that position, as amongst several hundreds, changes are constantly taking place. But it can be done where thorough harmony exists between the managing and the warehouse departments. Sometimes opposition arises between these, the former desiring to secure a large production, regardless of quality ; the latter checking this, owing to the necessity of maintaining the quality. The liability to this conflict is very difficult to prevent, and to do this in the smaller establishments the functions of manager and clothlooker are often combined in one person.

A manager, who is a good disciplinarian, will see that his overlookers are at the mill at the proper time in the morning, and at each recommencement at meal hours, in order that they in turn may similarly influence their subordinate weavers. Steady attention during working hours to their looms should be required from the weavers, and at the proper time to cleaning and oiling their machinery. All this can be secured by attention on the part of the overlookers, and where it is fully obtained the employer will be gratified at the quantity and quality of the production, and the economy with which it is accompanied. The operatives will be pleased with the amount of their earnings, and the establishment will gain character amongst those not connected with it, which will always ensure a good supply of hands. And better than all, the quality of the work produced will secure it repute in the market, by which the best prices will be ensured.

The warehouse is an exceedingly important department of a weaving mill. It is the room in which the production of the looms is received from the weavers, inspected, assorted, made up, and stored until despatched to the agent who sells the production, or to the merchant who may have purchased it, if it should be delivered direct. This is in the case where, as is usual in the great cotton manufacturing establishments of East Lancashire, the handling of the article ceases with the sale of the grey cloth. In the few

instances in which the manufacturer strictly so-called combines also the one of merchant, before leaving his possession the cloth undergoes what are technically called the finishing processes. These may be either bleaching, dyeing, or printing, and the routine is slightly varied according to the circumstances of the case. It may be, as in some instances, that the goods are despatched from the mills by the manufacturer to some finisher who treats them according to instructions, and then delivers them back to the manufacturer's warehouse, say in Manchester, whence they are sold in large or small lots, as required by customers. Probably, however, more than seventy-five per cent. of the production is disposed of in the "grey," as the unbleached and undyed stage of the cotton cloth is termed. It is, therefore, this phase of the business to which these and the following remarks are intended to apply.

Nearly all weaving is performed on what is called piece-work terms: that is, for a stipulated quantity and quality a certain sum is paid. These quantities are called "pieces" or "cuts," the former because they are pieces or portions of a warp, and the latter because they are such lengths as when woven may be properly cut from the warp in the loom. The manufacturer sells in the market, say 5,000 pieces of shirtings, jaconets, or mulls, and gives his manager orders to make them accordingly. In the process of sizeing the warps are marked in the proper lengths, and wound upon the loom beam until the latter is filled. An automatic indicator registers the number of pieces that are put upon each beam, and a ticket is issued therewith giving order, number, counts of yarns, quantity of ends in the warp, number of pieces contained upon the beam, the number of picks that have to be put into it, and the counts of the weft yarn with which it is to be woven. This information is an instruction to both tackler and weaver. The latter, when he has woven his first piece, takes the warp ticket with it to the warehouse, where he has the details entered

into the warehouse piece-book, and also upon a check or tallyboard, on which a receipt is given him for all the pieces he delivers into the warehouse. The proper keeping of this book entails considerable care, because disputes are liable to arise between the person having charge of it and weavers, who will sometimes declare that they have not been credited with all the pieces that they have woven. To the credit of the operative weavers it may be said that very few false allegations of this kind are made. When a dispute arises, the piece-book is the safest guide, as it may be assumed that it is less liable to be tampered with than are the check-boards of the weaver. The truth, however, can be almost with certainty ascertained from two sources: the first being the warehouse stock of the particular kind of cloth in dispute, which ought to be taken weekly after all the pieces at the close of the week have been made up; and the second by waiting until the warp is finished, by which it will be seen whether it closes with what should be the last piece. This, however, is not always satisfactory, as it may leave the matter in dispute two or three weeks, by which the weaver would be kept out of his or her money, or on the other hand, if a dishonest claim had been paid, it would probably be found that the weaver had left the establishment.

Cloth-looking is the careful examination of the cloth as it comes from the looms, its purpose being to keep up the standard of quality to the necessary degree of excellence, to secure for the production of the mill a good name in the market. The person to whom this function is entrusted is called the cloth-looker, and his duty is to carefully examine every piece to see that it is properly made, and free from faults and blemishes of every kind. There are two or three methods of performing this work, but substantially there is not much difference in the results, if the work in each case be conscientiously performed. The first may be said to be that of "flewing" it, which is probably the oldest form, and a survival from the days of handloom

weaving. When the weaver has completed a piece of cloth, it is "pulled out" from the cloth beam of the loom, being folded in "flews" or layers upon the slay cap of the loom. Probably the word "flew" is derived from turning the folds over in a manner that might be described as flying them; or it may be a corruption of the word "fold." These folds are of course made from the length of the fabric, and are usually from about ten to fifteen inches broad. When the piece is all drawn off the cloth beam, it is doubled upon itself in the direction of the width, and in this form delivered into the warehouse. The clerk who has charge of the piece-book pencils upon it the number of the loom from which it has come, in order that if required the weaver may be identified. The cloth-looker takes up his position in front of a long bench of about a yard and a half wide, and at a point with a window in front of him to afford plenty of light. Taking up the piece to be examined, he first weighs it, which shows him whether it is substantially right in the length, and made of correct yarns, the right weight being known. Should it vary from the requirement in this respect, and yet be correctly made from the proper yarn, and the length also be right, it may require that the cloth-looker to direct that heavier or lighter weft be used, if the conditions of the order render that necessary. Where the requirement is simply a guarantee that certain counts of yarn shall be used, the introduction of heavier weft may not be requisite. The variability in the weight of the cloth mainly arises from the varying humidity of the atmosphere, the weight being greatest in damp and rainy weather, and least in the cold dry frosty weather of winter, the dry periods of spring when east winds prevail, and the hot and dry weather of summer. Should the piece, however, be all right in this respect, the cloth-looker throws open the fold in its width, and arranging it in front of himself, and in a line diagonal to the window, rapidly and skilfully turns over the flews,

or folds, of the cloth, carefully inspecting it as he proceeds. Any fault or departure from the even texture is easily observed. Having thus inspected the piece halfway across its width, for its whole length he throws it over, by which the other side is brought to his hand, when he rapidly repeats the process. Should any fault be discovered in the weaving, the piece is laid aside, and the attention of the weaver called to it, and a reprimand given, or a small abatement made such as may meet the necessities of the case.

In the second method the cloth-looker has his bench painted black in front of him, and placing the pieces at the top, takes hold of the end, and draws it evenly over the dark surface, which shows up every fault with great distinctness. This, however, is a very laborious method for the cloth-looker, and it has been obviated by an arrangement in which a pair of rollers draw down the cloth, these being actuated by a small band brought from one of the shafts in another part of the works. This is, perhaps, the best plan of examining cloth, provided proper attention is given to it when it is passing over the board.

The points to which cloth-lookers are required chiefly to direct their attention are to see that the weights, lengths, and widths of the cloths are correct; that they are free from weavers' defects or faults, which may be enumerated as being thick and thin places, made chiefly in stopping and starting the looms; broken warp threads not being pieced with sufficient promptitude; "floats" or scobs, caused by a broken warp thread getting entangled in the shed, and preventing the warp from "clothing" as the weaving proceeds, which results in a fault little better than a hole. These defects are incident to weaving, and require carefulness and strict attention on the part of the weaver to keep them out. For all defects clearly due to his negligence the weaver ought to be held directly responsible. There is another class of faults which may and mostly do arise from the loom being out of order: bad

selvages, uneven cloth, thick, and thin places. The weaver is properly held to be responsible for these until the attention of the overlooker has been called to the faulty condition of the loom. They are sometimes difficult to cure, but the responsibility of the weaver is not discharged by any failure of the overlooker to mend the matter, as the loom ought to be stopped until it is made right, and the overlooker held to the task until the defect is cured.

The position of cloth-looker is the most onerous and difficult to maintain of any in a mill. His hand is literally against every man, and woman too, and theirs against him. In many cases, in fact probably more than half, he is directly responsible only to his employer, not being subordinate to the manager. This arises to a certain extent from the necessity of placing him above the risk of any pressure being brought to bear upon him to make him swerve from what he conceives to be necessary, from his point of view, to secure and maintain the interests of his employer. The interests of the overlookers and managers of mills, the former especially, being paid a commission upon the earnings of the weavers, are to some extent in conflict with the duties of the cloth-looker, as they are more anxious to secure a large production than careful of the quality, which would interfere with the realization of the former object. The employer should be exceedingly careful in the selection of an intelligent and equitably minded man for the post of cloth-looker. He should be skilful, prudent, cool in temper, resolute in the assertion and maintenance of his decisions, of strict integrity and high moral principle. He should have nothing of a weak or revengeful disposition within him, and should never display either favour or fear in his dealings with the weavers. A conscientious man having these traits of character placed in this post will be found to be almost invaluable to an employer. The principal of the establishment should always energetically support the authority and moral influence of the cloth-looker ; even if

he should happen to make a mistake, a semblance of maintaining the position should be kept up, whilst a real retreat should be made from the untenable attitude, which can be effected by pointing out to the cloth-looker in a private interview the mistake he may have made. This support should be given as a matter of policy, because the mass of weavers cannot always discriminate between the merits or demerits of the dispute, and would look upon the humiliation of their common enemy as a victory for themselves, that if followed up and repeated would be an advantage to all.

After the cloth has been examined, it is hooked up on a frame, or plaited in a machine generally in yard folds, is folded into smaller compass, and five, ten, or more pieces made into one bundle, tied up, and stored ready for despatch to its destination. This part calls for little remark beyond the observation that the work should be neatly and tidily performed, and the selvages of the cloth carefully brushed in, or to take off the loose threads of weft; and every other means should be taken to give the goods a smart, clean-looking appearance, in order that they may make a good impression when delivered.

Too often the warehouse staff is overworked. Many employers seem to think it good policy to save every penny they can in this department, and therefore overwork both cloth-lookers, hookers, and makers-up. This is a bad policy, and is sure to entail much greater loss in another direction. The cloth-looker cannot do his duty properly, and faults in the cloth must frequently escape his notice. This can never occur without the knowledge of the weaver who has sent in the bad work. When they once discover that bad work has a chance of escaping detection, it is always a strong temptation to them to "try it on," by which the whole tone of the establishment is speedily lowered. Further, when the cloth is sent to the merchant in Manchester, it is nearly always carefully examined by cloth-lookers who have plenty of time in

which to do their work, but in most cases no practical knowledge of the weaving processes; and should the delivery in any sense present an untidy appearance, it is prejudiced in their eyes, and the actual defects are multiplied in number and magnified in size by their ignorance. Had the delivery been made up and smartly finished with the loose threads carefully brushed away, the chances would have been in favour of their passing without complaint or risk of rejection. A staff of warehouse hands sufficient to properly perform the work, it may be affirmed with perfect confidence, will always be not only the most economical but also far more profitable than one which is insufficient and overworked.

The vicious practice of buying low-priced yarns because they are apparently cheap is strongly to be reprobated. During long observation, the writer has never seen it result in permanent benefit. Good weavers will not struggle with bad yarns, because they increase their work and diminish their earnings. They will take the first opportunity of transferring their services to neighbouring establishments the owners of which have a more enlightened conception of their interests than to pursue such a policy. The employer in the former instance is soon left with a class of weavers who cannot even make good work out of good stuff, let alone out of the inferior material with which he supplies them. The consequence is that the reputation of the firm rapidly declines in the market, the production of the establishment fetches a lower price, losses are frequently made upon rejected or cancelled orders, and too often the end thereof is bankruptcy and ruin. The best advice that can be given regarding buying yarns is: aim to procure the highest quality that the circumstances require, and never descend below a good average. A policy of this kind will secure for a mill good weavers, a large production, a high quality of cloth, and the best prices of the market, all of which it will be admitted are highly desirable.

Isolated strikes were formerly a great trouble in the management of a mill. These had their origin very frequently owing to complaints as to the quality of the material supplied to the winding or weaving department. Bad twist or warp yarn might produce a strike amongst either the winders, warpers, or weavers; or bad weft amongst the latter. Owing, however, to the great improvements that have taken place in the spinning department of the trade in which these faults nearly always originated, they have become almost obsolete. The best way to avoid these is for the yarn buyer never to buy "cheap lots" unless guaranteed to be right in quality, so that if they fail in that essential point they may be returned without difficulty.

In a large establishment containing, perhaps, several hundred workpeople of both sexes, it sometimes happens that improprieties of a serious kind occur between the foremen and female *employées.* The master of the establishment should have a quick eye and ear for the detection of these matters, because whenever they occur he may depend upon it they will involve a great sacrifice of his interests. Favouritism will be shown, bad work will be hidden or condoned, and insufficient quantities will be accepted without rebuke. Far graver mischiefs than these also occasionally result. It is far from being advocated here that employers or managers should take cognizance of what occurs outside the walls of the mill, unless such acts from their character lead to disorganization or serious relaxation of discipline within, which may easily and does often occur. This should immediately be repressed, and with a very stern hand, as the bad consequences are as great as in the demoralization caused by cases of drunkenness.

There is one aspect of mill management that cannot properly be overlooked. This is the subjection of spinning and weaving mills to the Factory Acts, but especially the latter, for the control of which some special legislation

has in addition been passed. We refer to the Cotton Cloth Factories Act. Taking Factory legislation altogether an important chapter might be written upon how best to conform to or deal with its requirements. But space precludes more than a brief reference.

The manager of a mill ought to make himself acquainted to a reasonable extent with the requirements of the law, and in order to do this should procure a small treatise termed, "The Factory Acts," by Mr. Alexander Redgrave, late Chief Inspector of Factories. This should be carefully studied. From it an intelligent manager will easily learn his obligations, responsibilities, and rights. The latter are more considerable than are generally supposed, and if insisted upon will preserve him from much annoyance. Unfortunately our factory laws have received their colouring from the traditions of the evil days of factory life in the early part of the century. Throughout them it is assumed that the employer is the author of all their infractions, and he is accordingly mulcted on every opportunity. This assumption, whatever it might have been in the early times referred to, is not correct to-day. But acting upon it, and further influenced by a second reason, the Home Office always directs the prosecution of the employer, even when it is as clear as any object seen in a summer day that the offender is one of the operatives, and that the law has been broken in spite of instruction to the contrary. This second reason is not often suspected: Her Majesty's Treasury object to provide the means for insuring the observance of the law, practically declaring that prosecutions of offenders must pay their own way, and not be a burden upon the State. The result is that the inspectors, whenever they detect operatives breaking the law, take action against their employers, because in the almost certain event of a conviction following they are sure of getting their costs. Experience has shown them that if they take the real offender, though they may get a conviction, getting the costs is another matter altogether.

Not long ago, in a case which came closely under the notice of the writer, an inspector prosecuted an employer and lost the case, yet wanted his costs from the person who was proved not to have been the offender. He said, "The Treasury would want them," and thus let the cat out of the bag. Treatment of this kind is iniquitous, and every person entrusted with the management of a mill subject to the Factory Acts, should defend himself from it. There is a provision in the Act itself enabling him to do it. It is Clause 87 of the Factory and Workshops Act, 1878. For the benefit of managers who are often unfairly harassed by these prosecutions, the clause is here transcribed:

"87. Where the occupier of a factory or workshop is charged with an offence against this Act he shall be entitled, upon information duly laid by him, to have any other person whom he charges as the actual offender, brought before the court at the time appointed for hearing the charge; and if after the commission of the offence has been proved, the occupier of the factory or workshop proves to the satisfaction of the court that he had used due diligence to enforce the execution of the Act, and that the said other person had committed the offence in question without his knowledge, consent, or connivance, the said other person shall be summarily convicted of such offence, and the occupier shall be exempt from any fine."

It was by availing himself of this defensive clause that the gentleman referred to above succeeded in putting the burden upon the shoulders where the inspector himself ought to have put it in the first instance. A second paragraph in Clause 87 enables the inspector, when it has been made to appear to his "satisfaction" that the employer is not the offender, he may proceed against the person by whom the law has been broken. For the reason above stated it is always a very difficult if not hopeless task to make it appear "to his satisfaction" that anybody but the employer has committed the offence. It

is probably within bounds to say that eighty-five per cent. of prosecutions by inspectors are for breaches of the law with which employers have had nothing whatever to do. It is equally safe to say that not twenty-five per cent. of the magistrates, nor fifty per cent. of their advising clerks, who adjudicate upon these offences, are aware of the existence of the clause we have quoted. It is here placed in the hands of managers and responsible persons, who may use it to ward off unjust prosecutions.

The offences which operatives may commit against the factory laws are almost innumerable, but the solitary defence employers have is the one quoted. Passing to the comparatively modern aspect of these Acts, a recent extension must be referred to. This piece of legislation is termed the "Cotton Cloth Factories Act," 1889, and applies to cotton weaving only. It is ordinarily called "The Steaming Act." It is to be regretted that the trade brought its provisions and penalties upon themselves by the abuse, on the part of a number of employers, of a good principle—that of increasing the humidity of the atmosphere of their weaving sheds by the injection of steam. The operatives protested against the abuse of this, and the result was the Act named.

A very brief elucidation of its principles must suffice. The atmosphere at all times holds in suspension a quantity of water in the form of vapour. This varies with times and seasons. It is a fact known to every cotton spinner and manufacturer that cotton works best and makes least waste in a humid atmosphere, and worst in a relatively dry one, such as occurs in the heats of summer, the east winds of spring, and the dry frosts of winter. In all these conditions the introduction of water by which the atmospheric humidity was increased was found to be beneficial. This led to the discovery that the atmosphere would absorb moisture up to the point of saturation, or the point when rain begins to fall, and that if filled nearly to this state a greater weight of cloth could be obtained from a

certain amount of material than was the case in average conditions. It was the abuse of this discovery that led to the enactment of the Act we have named.

The amount of water which the atmosphere will hold in suspension is considerable. Take for illustration a summer day with a temperature of 82° Fahr., a cubic foot of air will then hold 11·8 grs.; at 70° Fahr., 8·2, while at 100° Fahr. it will hold just ten times as much as at 32° Fahr., or the freezing point of water.

The humidity of the atmosphere is measured by instruments termed hygrometers, of which there are several varieties. The Cotton Cloth Factories Act prescribes the use of that known as Mason's hygrometer, which consists of two thermometers of exactly the same size supported on a suitable stand. One of these is known as the dry bulb, and is generally placed on the left-hand side of the stand. The other is termed the wet bulb. The bulb of this is enclosed in a piece of muslin, from which depends a few lengths of soft-twisted yarn, which dip into a small glass bottle placed below. The water by capillary attraction is drawn up to the muslin round the bulb and saturates it. The large amount of surface exposed facilitates evaporation, and consequently gradually exhausts the water in the bottle, which requires renewal from time to time. It will be obvious from this that the rate of evaporation must depend partly on the temperature at any given time, and partly on the amount of aqueous vapour already held in the atmosphere. If the temperature be low, and the air nearly saturated, the evaporation will be small; but if it be high, and the air comparatively dry, then it will be much greater. It is an axiom in thermostatics that when a liquid is converted into a vapour heat must be taken up to effect the change. Therefore, the water which is evaporated from the muslin requires heat to effect the change, and this it obtains from the bulb of the thermometer, and so reduces its temperature that it registers a lower degree than does the dry bulb, which is not exposed to such

influence. If the rate of evaporation is great, then a great deal of heat is absorbed, and a greater difference is shown between the readings of the two thermometers. But if the air be nearly saturated with vapour, the rate of evaporation will be slow, and the difference between the readings will be reduced considerably, because of the absorption of a less amount of heat from the wet bulb. Hence it will be seen that by noting the differences in the readings of the two thermometers a fair idea of the amount of water present in the atmosphere can be obtained.

Careful experiments have been made to ascertain the proportion of aqueous vapour in the air at different temperatures and under different conditions. The conclusions arrived at are included in the following table, which is the schedule of temperatures and humidity prescribed by the Cotton Cloth Factories Act as those under which work shall be conducted in weaving sheds. This table is the one last sanctioned by the Secretary of State for the Home Department. It gives the maximum limits of humidity at given temperatures, and is therefore of special interest to cotton manufacturers and mill managers:

Grains of vapour per cubic foot of air.	Dry bulb thermometer readings. Degrees Fahr.	Wet bulb themometer readings. Degrees Fahr.	Percentage of humidity. Saturation = 100
1·9	35	33	80
2·0	36	34	82
2·1	37	35	83
2·2	38	36	83
2·3	38	37	84
2·4	40	38	84
2·5	41	39	84
2·6	42	40	84
2·7	43	41	84
2·8	44	42	84
2·9	45	43	85
3·1	46	44	86
3·2	47	45	86
3·3	48	46	86
3·4	49	47	86
3·5	50	48	86
3·6	51	49	86
3·8	52	50	86
3·9	53	51	86
4·1	54	52	86
4·2	55	53	86
4·4	56	54	87
4·5	57	55	87
4·7	58	56	87
4·9	59	57	88
5·1	60	58	88
5·2	61	59	88
5·4	62	60	88
5·6	63	61	88
5·8	64	62	88
6·0	65	63	88
6 2	66	64	88
6·4	67	75	88
6·6	68	66	88
6·9	69	67	88

Grains of vapour per cubic foot of air.	Dry bulb thermometer readings. Degrees Fahr.	Wet bulb thermometer readings Degrees Fahr.	Percentage of humidity. Saturation = 100.
7·1	70	68	88
7·1	71	68·5	88·5
7·1	72	69	84
7·4	73	70	84
7·4	74	70·5	81·5
7·65	75	71·5	79
7·7	76	72	81·6
8·0	77	73	72
8·0	78	73·5	77
8·25	79	74·5	77·5
8·55	80	75·5	77·5
8·6	81	76	76
8·65	82	76·5	74
8·85	83	77·5	74
8·9	84	78	72
9·2	85	79	72
9·5	86	80	72
9·55	87	80·5	71
9·9	88	81·5	71
10·25	89	82·5	71
10·3	90	83	69
10·35	91	83·5	68
10·7	92	84·5	68
11·0	93	85·8	68
11·1	94	86	66
11·5	95	87	66
11·8	96	88	66
11·9	97	88·5	65·5
12·0	98	89	64
12·3	99	90	64
12·7	100	91	64

This table embodies unchanged the figures of the previous schedule, which is now extended to meet cases of temperature below 60° and above 95° Fahr. Column 4

is new, and expresses the percentages of saturation, that is, of the total amount of vapour which the air at that particular dry bulb temperature, is capable of taking up, equivalent to column 1. It will be a practical guide to manufacturers, who will thus perceive readily that the higher the temperature above 73° the drier is the permitted atmosphere.

Whilst the manufacturer has little control over the reading of the dry bulb thermometer which registers the actual temperature of the shed, in winter the latter may be kept at a fairly comfortable working point by introducing heat through the usual steam-pipe appliances or other suitable means. In summer artificial warming is not required. But whatever the reading of the dry bulb is, to avoid the risk of penalties he must keep the wet bulb down to the corresponding temperature given in the schedule. This is accomplished by carefully regulating the amount of steam injected into the atmosphere of the shed, and the attention paid to ventilation. He may of course permit the two thermometers at any time to show a greater difference in the temperatures than that given in the table, because this would indicate a drier atmosphere than that specified, which is the minimum, or least dry, the law allows. If the thermometers show temperatures closer together than those shown in the table, the atmosphere is damper than is allowed by the law, and the employer runs the risk of incurring the penalties laid down for infringing its provisions.

CHAPTER XVI.

Standard Lists of Wages.

The origin of Standard Lists of Wages.—Wages in the transition period; struggles; and the evolution of the "Blackburn Standard List."—Its basis.—Its authors.—Adoption with modifications by other districts.—Necessity for a Uniform List.—The advantages of these Lists to both employers and employed.—The Uniform List:—The standard; width of loom; allowances for broader cloth than admitted by rule; Allowances for narrow cloths, with tables; Reeds; Picks; Twist; Weft; Four-staved Twill; Splits; additions and deductions; time of List coming into operation.—The conferences at which the List was drawn up and signed.—Portions of the old Blackburn List incorporated with the new.—Plain dhooties; dobby dhooties; dhooty headings; additions upon plain cloth prices for satins, drills, drillets; for lenos; for double-lift jacquards; for dobby and tappet motions; exceptions.—Blackburn prices for winding; for patent beam warping; for tape-sizeing or slashing; for looming and drawing; overlookers' poundage.—Burnley prices for winding; for looming and drawing; overlookers' poundage.—Colne District Coloured Goods Weaving List.—Oldham Velvet Weaving List.—Bolton Quilt Weaving List.—Specialties in looms, and the districts in which they are made.—Blackburn makers: Messrs. Henry Livesey, Limited; John Dugdale and Sons; William Dickinson and Sons; Willan and Mills.—Burnley makers: Messrs. Butterworth and Dickinson.—Bury makers: Messrs. Robert Hall and Sons; Hacking and Co.—In other towns: Messrs. Platt Bros. and Co., Limited; Smith Bros.; Richardson, Tuer and Co.—Preparation weaving machinery: Howard and Bullough.—Winding machines: Mr. Joseph Stubbs; Messrs. John Horrocks and Sons; Brooks and Doxey; J. and T. Boyd; and Mr. Thomas Coleby.—Temples and temple makers: Messrs. Lupton Bros.; and J. Blezard and Sons.—Jacquard makers: Messrs. Devoge and Co.; James McMurdo.—Card cutting and card lacing machines: Messrs. William Ayrton and Co.—The end.

IN the cotton manufacturing districts it will generally be found that there is in existence some "standard list," or rate of payment, by which wages are ruled in the

several departments of the establishment. It is not necessary here to discuss the wisdom or unwisdom of the parties to the "Unions" by which these are imposed or maintained—for the "Union" of one side has its counterpoise on the other. Facts, however, cannot be ignored, and it would be folly to shut one's eyes to the power which has accrued to the body of the operatives from combination. In past times serious disputes have arisen between employers and their operatives on the wages question, and efforts have been made by both sides to coerce the other, the instrument employed being combination. This has been met by counter combination, and out of the struggles that have taken place the compromises on the points in dispute have resulted in the establishment of the district standard lists of payment. The first to receive wide recognition and establish its importance was that agreed upon between the employers and operatives of Blackburn in the year 1853.

The Blackburn list became known throughout the cotton trade as the "Blackburn Standard List." Previously to its adoption there was no recognized standard rate of wages for weaving, and the work in its preparatory processes. The trade had only too recently emerged from the hand-loom or manual stage of existence, in which wages were constantly fluctuating, advancing and receding with every change of the market. As many of the hand-loom employers had, and others were transferring their capital and enterprise to the mechanical system then rapidly being perfected, they brought with them the habits to which they had been accustomed of advancing or reducing wages—mostly the latter—on any, or without any pretext whatever. The only check to these proceedings was the resistance of the operatives, who would "strike." These episodes mainly depended upon the presence amongst them of an intelligent and spirited leader, of whom there were not a few, but amongst whom there was no combination or co-operative effort. Thus

numerous and serious irregularities in the wages rate prevailed. From 1848 to 1852 many reductions took place at individual establishments, and it was in an attempt to recover some of these that a combined and determined effort, soon after the inauguration of a complete system of free trade which induced a remarkable degree of prosperity, was made. A 10 per cent. advance of wages was demanded. The movement spread over the entire cotton trade, and was successful until Preston was reached, where, in the great strike of 1853-4 it was defeated.

When the advance was conceded by the Blackburn employers, the question naturally arose as to the basis upon which it should be paid. Inquiries soon showed that the differences existing amounted in some cases almost to 10 per cent. It was then agreed that particulars should be obtained from all the mills in the town and district, an average be struck, and 10 per cent. advanced upon that. This was done.

It may be of interest to mention here that the contending parties had formed opposing combinations of a temporary character, no expectation being entertained that they would become permanent. The operatives had appointed Edward Whittle, one of those clever working men mathematicians who were not scarce amongst them in the first half of the present century, to be their secretary. The employers appointed Mr. William Birtwistle, a cotton manufacturer of their order, assisted by Mr. J. C. Fielden, then a young man in the service of Mr. Birtwistle. These were appointed to work out the details of the Blackburn Standard List, which afterwards became famous as the model upon which all subsequent weaving lists in Lancashire were founded.

This list, with suitable modifications, was quickly adopted as a basis and model by those of Preston, Chorley, and Burnley, the subjacent districts bringing themselves within the comprehension of one or other of these. When the wages movement was wrecked at Preston, after a long

and expensive strike, supported by all the manufacturing districts of Lancashire, the 10 per cent. gained in Blackburn and other districts was soon lost. The operatives, however, had discovered that they were strong when united, and accordingly determined to found a permanent union. It was out of this resolution sprang the celebrated Blackburn Powerloom Weavers' Association. District after district joined it until it embraced nearly the whole of East Lancashire. Some dissensions arose about 1858 which led to a secession, and the formation of the East Lancashire Powerloom Weavers' Association, of which Mr. Thomas Birtwistle, now a factory inspector, became secretary, a position which he held until about 1893, when he received the appointment of "Particulars" inspector.

The principles adopted in these lists have continued to govern the trade ever since, any changes that have occurred having been made by reductions or advances of given percentages from the standard rates embodied in them. As, however, the rates paid under them were not uniform, some districts obtained an important advantage over others because of their ability to undersell them in the market. Burnley was a notable illustration of the working of economic principles in this connection. It obtained a large and rapid concentration of the industry to the disadvantage of the other districts. The present writer drew the attention of the trade to this result in the pages of the "Textile Mercury," and pressing it upon them, a movement was set on foot which resulted in the draughting and adoption of the Uniform Standard List in the weaving branch of the cotton trade. This list came into force in the beginning of August, 1892.

Those who remember the state of matters before these "Standards" were established will readily admit that they have been of the greatest service to the trade. The interest of both sides, therefore, consists in the honourable observance of the compact, and when doubt arises in the minds of the operatives as to the *bonâ fides* of their employer in his

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regard for it, the counsel of the writer of these pages is that every opportunity for the strictest investigation should be promptly offered. The belief in the minds of a large body of workpeople, though it may be a mistaken one, that they are not being treated honestly, will lead to such mischievous results, springing from sentiments of retaliation, that any little advantage arising from fractional divergencies from accurate conformity to the List will have to encounter a serious offset. When doubts arise on this point the Secretary of the Weavers' Union should always be a welcome visitor, because this throws upon him the task of disabusing their minds of any misconception—a task which is much more easily accomplished by him than their employer, because his interests are regarded as being identical with theirs. The question being one of calculation, the proper conclusion is easily enough demonstrated, and with a disposition to act justly on both sides, the difficulty is speedily cleared away.

The following is a copy of the Uniform List, probably the most important ever drawn up for the weaving branch of the trade.

(1) The Standard.

The standard upon which this list is based is an ordinarily-made loom, 45 inches in the reed space, measured from the fork grate on one side to the back board on the other, weaving cloth as follows:

Width.—39, 40, or 41 inches.

Reed.—60 reed, 2 ends in one dent, or 60 ends per inch.

Picks.—15 picks per quarter inch, as ascertained by arithmetical calculation, with $1\frac{1}{2}$ per cent. added for contraction.

Length.—100 yards of 36 inches measured on the counter. Any length of lap other than 36 inches to be paid in proportion.

Twist.—28's or any finer numbers.

Weft.—31's to 100's both inclusive.

Price.—30*d.* or 2*d.* per pick.

(2) Width of Looms.

A 45-inch reed space loom being taken as the standard, $1\frac{1}{2}$ per cent. shall be added for each inch up to and including 51 inches; 2 per cent. from 51 to 56 inches; $2\frac{1}{2}$ per cent. from 56 to 64 inches; and 3 per cent. from 64 to 72 inches. $1\frac{1}{4}$ per cent. shall be deducted for each inch from 45 to 37 inches inclusive; and 1 per cent. from 37 to 24 inches, below which no further deduction shall be made. For any fraction of an inch up to the half no addition or deduction shall be made, but if over the half the same shall be paid as if it were a full inch. All additions or deductions under this clause to be added to or taken from the price of the standard loom, 45 inches.

Deducted from Standard.				Added to Standard.			
Loom.	Per Centage.	Loom.	Per Centage.	Loom.	Per Centage.	Loom.	Per Centage.
Inches.		Inches.		Inches.		Inches.	
24	23	35	12	46	$1\frac{1}{2}$	60	29
25	22	36	11	47	3	61	$31\frac{1}{2}$
26	21	37	10	48	$4\frac{1}{2}$	62	34
27	20	38	$8\frac{3}{4}$	49	6	63	$36\frac{1}{2}$
28	19	39	$7\frac{1}{2}$	50	$7\frac{1}{2}$	64	39
29	18	40	$6\frac{1}{4}$	51	9	65	42
30	17	41	5	52	11	66	45
31	16	42	$3\frac{3}{4}$	53	13	67	48
32	15	43	$2\frac{1}{2}$	54	15	68	51
33	14	44	$1\frac{1}{4}$	55	17	69	54
34	13	45	Standard	56	19	70	57
				57	$21\frac{1}{2}$	71	60
				58	24	72	63
				59	$26\frac{1}{2}$		

(3) Broader Cloth than Admitted by Rule.

All looms shall be allowed to weave to within 4 inches of the reed space, but whenever the difference between the width of cloth and the reed space is less than 4 inches it

shall be paid as if the loom were 1 inch broader, and if less than 3 inches, as if it were $2\frac{1}{2}$ inches broader.

(4) Allowance for Cloth 7 to 15 inches Narrower than the Reed Space.

When the cloth is from 7 to 15 inches inclusive narrower than the reed space of the loom in which it is being woven, a deduction in accordance with the following tables shall be made. No further deduction shall be made when cloth is more than 15 inches narrower than the reed space, or when cloth is narrower than 18 inches. Fractions of an inch are not to be recognized under this clause.

Cloth.	72-in. Loom.	Cloth.	71-in. Loom.	Cloth.	70-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
65	1·38	64	1·41	63	1·43
64	2·76	63	2·81	62	2·87
63	4·14	62	4·22	61	4·3
62	5·52	61	5·62	60	5·73
61	6·9	60	7·03	59	7·17
60	8·28	59	8·44	58	8·6
59	9·66	58	9·84	57	9·79
58	11·04	57	11·02	56	10·99
57	12·19	56	12·19	55	12·18

Cloth.	69-in. Loom.	Cloth.	68-in. Loom.	Cloth.	67-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
62	1·46	61	1·49	60	1·52
61	2·92	60	2·98	59	3·04
60	4·38	59	4·47	58	4·56
59	5·84	58	5·96	57	5·83
58	7·31	57	7·2	56	7·09
57	8·52	56	8·44	55	8·36
56	9·74	55	9·69	54	9·63
55	10·96	54	10·93	53	10·9
54	12·18	53	12·17	52	12·16

ALLOWANCES FOR NARROW CLOTH—*Continued.*

Cloth.	66-in. Loom.	Cloth.	65-in. Loom.	Cloth.	64-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
59	1·55	58	1·58	57	1·35
58	3·1	57	2·91	56	2·7
57	4·4	56	4·23	55	4·05
56	5·69	55	5·55	54	5·4
55	6·98	54	6·87	53	6·74
54	8·28	53	8·19	52	8·09
53	9·57	52	9·51	51	9·44
52	10·86	51	10·83	50	10·79
51	12·16	50	12·15	49	11·87

Cloth.	63-in. Loom.	Cloth.	62-in. Loom.	Cloth.	61-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
56	1·37	55	1·4	54	1·43
55	2·75	54	2·8	53	2·85
54	4·12	53	4·2	52	4·28
53	5·49	52	5·6	51	5·7
52	6·87	51	7·	50	7·13
51	8·24	50	8·4	49	8·27
50	9·62	49	9·51	48	9·41
49	10·71	48	10·63	47	10·55
48	11·81	47	11·75	46	11·69

Cloth.	60-in. Loom.	Cloth.	59-in. Loom.	Cloth.	58-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
53	1·45	52	1·48	51	1·51
52	2·91	51	2·96	50	3·02
51	4·36	50	4·45	49	4·23
50	5·81	49	5·63	48	5·44
49	6·98	48	6·82	47	6·65
48	8·14	47	8·	46	7·86
47	9·3	46	9·19	45	9·07
46	10·47	45	10·38	44	9·98
45	11·63	44	11·26	43	10·89

ALLOWANCES FOR NARROW CLOTH—*Continued.*

Cloth.	57-in. Loom.	Cloth.	56-in. Loom.	Cloth.	55-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
50	1·54	49	1·26	48	1·28
49	2·78	48	2·52	47	2·56
48	4·01	47	3·78	46	3·85
47	5·25	46	5·04	45	5·13
46	6·48	45	6·3	44	6·09
45	7·72	44	7·25	43	7·05
44	8·64	43	8·19	42	8·01
43	9·57	42	9·14	41	8·97
42	10·49	41	10·08	40	9·94

Cloth.	54-in. Loom.	Cloth.	53-in. Loom.	Cloth.	52-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
47	1·3	46	1·33	45	1·35
46	2·61	45	2·65	44	2·36
45	3·91	44	3·65	43	3·38
44	4·89	43	4·65	42	4·39
43	5·87	42	5·64	41	5·41
42	6·85	41	6·64	40	6·42
41	7·83	40	7·63	39	7·43
40	8·8	39	8·63	38	8·28
39	9·78	38	9·42	37	9·12

Cloth.	51-in. Loom.	Cloth.	50-in. Loom.	Cloth.	49-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
44	1·03	43	1·05	42	1·06
43	2·06	42	2·09	41	2·12
42	3·1	41	3·14	40	3·18
41	4·13	40	4·19	39	4·25
40	5·16	39	5·23	38	5·13
39	6·19	38	6·1	37	6·01
38	7·05	37	6·98	36	6·9
37	7·91	36	7·85	35	7·78
36	8·77	35	8·72	34	8·67

ALLOWANCES FOR NARROW CLOTH—*Continued.*

Cloth.	48-in. Loom.	Cloth.	47-in. Loom.	Cloth.	46-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
41	1·08	40	1·09	39	1·11
40	2·15	39	2·18	38	2·03
39	3·23	38	3·09	37	2·96
38	4·13	37	4·	36	3·88
37	5·02	36	4·91	35	4·8
36	5·92	35	5·83	34	5·73
35	6·82	34	6·74	33	6·65
34	7·72	33	7·65	32	7·57
33	8·61	32	8·56	31	8·5

Cloth.	45-in. Loom.	Cloth.	44-in. Loom.	Cloth.	43-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
38	·94	37	·95	36	·96
37	1·87	36	1·9	35	1·92
36	2·81	35	2·85	34	2·88
35	3·75	34	3·80	33	3·77
34	4·69	33	4·75	32	4·81
33	5·62	32	5·70	31	5·77
32	6·56	31	6·65	30	6·54
31	7·5	30	7·41	29	7·31
30	8·25	29	8·16	28	8·08

Cloth.	42-in. Loom.	Cloth.	41-in. Loom.	Cloth.	40-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
35	·97	34	·99	33	1·
34	1·95	33	1·97	32	2·
33	2·92	32	2·96	31	3·
32	3·9	31	3·95	30	3·8
31	4·87	30	4·74	29	4·6
30	5·65	29	5·52	28	5·4
29	6·43	28	6·32	27	6·2
28	7·21	27	7·11	26	7·
27	7·99	26	7·89	25	7·8

ALLOWANCES FOR NARROW CLOTH—*Continued.*

Cloth.	39-in. Loom.	Cloth.	38-in. Loom.	Cloth.	37-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
32	1·01	31	1·03	30	·83
31	2·03	30	1·85	29	1·67
30	2·84	29	2·67	28	2·5
29	3·65	28	3·49	27	3·33
28	4·46	27	4·32	26	4·17
27	5·27	26	5·14	25	5·
26	6·08	25	5·96	24	5·83
25	6·89	24	6·78	23	6·67
24	7·7	23	7·60	22	7·5

Cloth.	36-in. Loom.	Cloth.	35-in. Loom.	Cloth.	34-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
29	·84	28	·85	27	·86
28	1·69	27	1·7	26	1·72
27	2·53	26	2·56	25	2·59
26	3·37	25	3·41	24	3·45
25	4·21	24	4·26	23	4·31
24	5·06	23	5·11	22	5·17
23	5·9	22	5·97	21	6·03
22	6·74	21	6·82	20	6·9
21	7·58	20	7·67	19	7·76

Cloth.	33-in. Loom.	Cloth.	32-in. Loom.	Cloth.	31-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
26	·87	25	·88	24	·89
25	1·74	24	1·76	23	1·79
24	2·62	23	2·65	22	2·68
23	3·49	22	3·53	21	3·57
22	4·36	21	4·41	20	4·46
21	5·23	20	5·29	19	5·36
20	6·1	19	6·18	18	6·25
19	6·98	18	7·06		
18	7·85				

ALLOWANCES FOR NARROW CLOTH—*Continued.*

Cloth.	30-in. Loom.	Cloth.	29-in. Loom.	Cloth.	28-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
23	·9	22	·91	21	·93
22	1·81	21	1·83	20	1·85
21	2·71	20	2·74	19	2·78
20	3·61	19	3·66	18	3·7
19	4·52	18	4·57		
18	5·42				

Cloth.	27-in. Loom.	Cloth.	26-in. Loom.	Cloth.	25-in. Loom.
In.	Per cent.	In.	Per cent.	In.	Per cent.
20	·94	19	·95	18	·96
19	1·87	18	1·9		
18	2·81				

(5) REEDS.

A 60 reed being taken as the standard, $\frac{3}{4}$ per cent. shall be deducted for every two ends or counts of reed from 60 to 50, but no deduction shall be made below 50. $\frac{3}{4}$ per cent. shall be added for every two ends or counts of reed from 60 to 68; 1 per cent. from 68 to 100; $1\frac{1}{2}$ per cent. from 100 to 110; and 2 per cent. from 110 to 132. All additions or deductions under this clause to be added to or taken from the price of the standard, 60 reed.

(5) REEDS—*Continued.*

Deducted from Standard.		Added to Standard.			
Count of Reed.	Per Centage.	Count of Reed.	Per Centage.	Count of Reed.	Per Centage.
50	$3\frac{3}{4}$	62	$\frac{3}{4}$	98	18
52	3	64	$1\frac{1}{2}$	100	19
54	$2\frac{1}{4}$	66	$2\frac{1}{4}$	102	$20\frac{1}{2}$
56	$1\frac{1}{2}$	68	3	104	22
58	$\frac{3}{4}$	70	4	106	$23\frac{1}{2}$
60	Standard	72	5	108	25
		74	6	110	$26\frac{1}{2}$
		76	7	112	$28\frac{1}{2}$
		78	8	114	$30\frac{1}{2}$
		80	9	116	$32\frac{1}{2}$
		82	10	118	$34\frac{1}{2}$
		84	11	120	$36\frac{1}{2}$
		86	12	122	$38\frac{1}{2}$
		88	13	124	$40\frac{1}{2}$
		90	14	126	$42\frac{1}{2}$
		92	15	128	$44\frac{1}{2}$
		94	16	130	$46\frac{1}{2}$
		96	17	132	$48\frac{1}{2}$

(6) PICKS.

Low.—An addition of 1 per cent. shall be made for each pick or fraction of a pick below 11, thus:

Below 11 down to and including 10, 1 per cent.
„ 10 „ „ 9, 2 „
„ 9 „ „ 8, 3 „
„ 8 „ „ 7, 4 „

and so on, adding 1 per cent. for each pick or fraction thereof.

High.—An addition of 1 per cent. per pick shall be made whenever they exceed the following, if using

Weft below 26's when picks exceed 16
„ 26's to 39's inclusive „ 18
„ 40's and above „ 20

In making additions for high picks any fraction of a pick less than the half shall not have any allowance; exactly the half shall have ½ per cent. added; any fraction over the half shall have the full 1 per cent. added.

(7) Twist.

The standard being 28's, or finer, the following additions shall be made when coarser twist is woven in the following reeds:

Below 28's to 20's in	64 to 67	reed inclusive,	1	per cent.
	68 to 71	„ „	2	„
	72 to 75	„ „	3	„
Below 20's to 14's in	56 to 59	„ „	1	„
	60 to 63	„ „	2	„
	64 to 67	„ „	3	„

and so on at the same rate. When twist is woven in coarser reeds no addition shall be made.

(8) Weft.

Ordinary Pin Cops.—The standard being 31's to 100's both inclusive, shall be reckoned equal. Above 100's 1 per cent. shall be added for every 10 hanks or fraction thereof. In lower numbers than 31's the following additions shall be made:

For 30's,	add	1	per cent.
„ 29's, 28's,	„	2	„
„ 27's, 26's,	„	3	„
„ 25's, 24's,	„	4½	„
„ 23's, 22's,	„	6½	„
„ 21's, 20's,	„	8	„
„ 19's, 18's,	„	10½	„
„ 17's, 16's,	„	13	„
„ 15's, 14's,	„	16	„

Large Cops.—When weft of the following counts is spun into large cops so that there are not more than 19 in one pound, the following additions shall be made in place of the allowance provided for pin cops in preceding table:

For 29's, 28's,	add	1	per cent.
,, 27's, 26's,	,,	2	,,
,, 25's, 24's, 23's,	,,	3	,,
,, 22's, 21's, 20's,	,,	4½	,,
,, 19's, 18's,	,,	6	,,
,, 17's, 16's,	,,	8	,,
,, 15's, 14's,	,,	10	,,

(9) Four-Staved Twills.

Low Picks.—In four-staved twills an addition of 1 per cent. for each pick or fraction thereof below the picks mentioned in the following table shall be made when using weft as follows:

Below 26's, the addition shall begin at			13
26's to 39's inclusive	,,	,,	14
40's and above	,,	,,	15

High Picks.—When using weft

below 26's, the addition for high picks shall begin at				21
26's to 39's inclusive	,,	,,	,,	22
40's and above	,,	,,	,,	23

In making additions for high picks, any fraction of a pick less than the half shall not have any allowance; exactly the half shall have ½ per cent. added; any fraction over the half shall have the full 1 per cent. added.

(10) Splits.

The following additions shall be made for splits:

One split, uncut, add 5 per cent.
Two splits, ,, ,, 7½ ,,

Empty dents only shall not be considered splits.

(11) Additions and Deductions.

All the foregoing additions and deductions shall be made separately.

This list is subject to a reduction of 10 per cent.

This list shall come into force after the first making-up day in August for cloths requiring a fresh calculation, and on the first making-up day in November next for all cloths.

The foregoing list has been framed at Conferences of Representatives consisting of Mr. T. Thornber, of Burnley; Mr. W. Taylor, of Blackburn; Mr. J. Wilding, of Preston; and Mr. Joshua Rawlinson, of Burnley, General Secretary, on behalf of the employers; and Mr. George Barker, of Blackburn; Mr. Luke Parker, of Preston; Mr. W. H. Wilkinson, of Haslingden; and Mr. Thomas Birtwistle, of Accrington, on behalf of the operatives.

Signed on behalf of the employers,

Joshua Rawlinson,

Secretary of the North and North-East Lancashire Cotton Spinners and Manufacturers' Association.

Signed on behalf of the operatives,

Thomas Birtwistle,

Secretary for the Northern Counties' Amalgamated Associations of Weavers.

June 24th, 1892.

Additions upon Plain Cloth Prices for the following Classes have not been altered.

Plain Dhooties.

There are two systems of paying for dhooties, but in the ultimate result there is very little difference.

The first that was adopted was as follows:

10 yard	dhooties	10 per	cent.	above list.
9 ”	”	11	”	”
8 ”	”	12	”	”
7 ”	”	13	”	”
6 ”	”	14	”	”
5 ”	”	15	”	”

The second is 10 per cent. upon all lengths without any deduction being made for width of cloth.

Dobby Dhooties.

Sixteen flush ends or under, with Calcutta heading, 20 per cent.

Sixteen ends and under, with Madras heading, to be paid 30 per cent. on list.

All other dobby borders to be paid 30 per cent., with prices for headings as per "Illustrated Coloured List," agreed upon March 15th, 1886.

Dhooty Headings—Extras for 40ss Yards.

Madras heading to be paid $\frac{1}{4}d.$ for 12, $\frac{1}{2}d.$ for 14 marks, if woven in looms over 39 inches wide, and 1*d.* for 16 to 20 marks, and $1\frac{1}{2}d.$ for 21 to 30, in whatever loom woven.

Large sarrie heading, with 1 shuttle 15 bars, to be paid 1*d.* extra. Small sarrie heading, with 1 shuttle 9 bars, to be paid $\frac{1}{2}d.$ extra.

Madras sarrie heading, with 2 shuttles 11 bars, including cord, to be paid $\frac{1}{2}d.$ extra.

Bombay chocolate heading, with 2 shuttles 14 bars, to be paid 1*d.* extra for 16 marks.

Madras chocolate heading, with 4 shuttles 18 bars, including cord, to be paid 1*d.* per cut extra.

Red Madras heading, with 2 shuttles 10 bars, including cord, to be paid $\frac{1}{4}d.$ for 12 headings, and $\frac{1}{2}d.$ for 14 if

woven in looms over 39 inches wide, and 1*d*. for 16 to 20 marks, and 1½*d*. for 21 to 30 in any loom.

What is known as 9-bar Bombay heading, with 1 shuttle 11 bars, to be paid 1*d*. extra for 16 marks.

Bombay chocolate heading, with 3 shuttles 14 bars, to be paid 1*d*. extra for 16 marks.

Ordinary Calcutta heading, with 5 bars, no extras.

Additions upon Plain Cloth Prices under an Agreement made with Nelson Employers, October 4th, 1886.

Satins, Drills, Drillets, etc.

Cloths up to and including 25 picks to be paid 8 per cent. on plain cloth prices, and for every additional pick or fraction beyond the half, an extra $\frac{1}{2}$ per cent. shall be added. These additions to be made in place of the allowance for picks in Clause 6.

Whenever the reed per $\frac{1}{4}$ inch exceeds the pick, $\frac{3}{4}$ per cent. shall be added for every additional two counts of reed above the number of picks.

Lenos.

For one doup, 70 per cent.; two doups, 80 per cent. on plain cloth prices.

Additions upon Plain Cloth Prices under an Agreement entered into at Chorley, February 24th, 1886.

Double-Lift Jacquards.

To be paid the following over and above plain cloth prices:

For plain grounds, 30 per cent.
For satin grounds, 25 „

Brocades, damasks, and stripes created by a variation

of the number of ends, 3, 4, or more in a dent, to be paid for by the number of ends per inch.

Picks 18 to 30, 1 per cent. per pick; from 30 to 40, $\frac{3}{4}$ per cent.; all above 40, $\frac{1}{2}$ per cent., instead of 1 per cent.

Lace brocades, 5 per cent. extra.

When single-lift machines are used, the scale shall be 10 per cent. higher than the above.

The above applies to jacquards only.

Dobby and Tappet Motions, Satins Excepted.

To be paid the following on plain cloth prices.

Up to and including:

4 staves,	12 per cent.	13 staves,	21 per cent.
5 ,,	13 ,,	14 ,,	22 ,,
6 ,,	14 ,,	15 ,,	23 ,,
7 ,,	15 ,,	16 ,,	24 ,,
8 ,,	16 ,,	17 ,,	25 ,,
9 ,,	17 ,,	18 ,,	26 ,,
10 ,,	18 ,,	19 ,,	27 ,,
11 ,,	19 ,,	20 ,,	28 ,,
12 ,,	20 ,,		

Stripes and other cloths, with more than two ends in a dent, to be paid for by the number of ends per inch.

In single shuttle checks, handkerchiefs, and all other special classes of goods in which more than one pick is put in one shed, all lost picks shall be counted.

Exceptions.

Plain handkerchiefs, 72 reeds and below, to be paid 5 per cent. extra.

Single shuttle cord checks, with more than two picks in one shed, to be paid $2\frac{1}{2}$ per cent. less.

Lace stripes, fly-overs, or any other goods of a special character, shall be paid extra as per special arrangement,

to be agreed upon by the Employers' and Operatives' Associations.

Blackburn Prices for Winding,

Subject to a Reduction of 10 *per cent.*

Counts of Yarn.	Lbs. of Twist for 12*d*.	Counts of Yarn.	Lbs. of Twist for 12*d*.
18's . . .	55 lbs.	38's . . .	32 "
20's . . .	52 "	40's . . .	31 "
22's . . .	49 "	46's . . .	27½ "
24's . . .	45½ "	50's . . .	26 "
26's . . .	42½ "	60's . . .	22 "
28's . . .	40 "	70's . . .	19 "
30's . . .	38 "	80's . . .	16½ "
32's . . .	36 "	90's . . .	14½ "
34's . . .	34½ "	100's . . .	13 "
36's . . .	33½ "		

Blackburn Prices for Patent Beam Warping,

Subject to a Reduction of 10 *per cent.*

Ends.	Price per cent. or 3,000 yards.	Ends.	Price per cent. or 3,000 yards.
300 . . .	3·12*d*.	410 . . .	4·11*d*.
310 . . .	3·21*d*.	420 . . .	4·20*d*.
320 . . .	3·30*d*.	440 . . .	4·40*d*.
330 . . .	3·39*d*.	460 . . .	4·60*d*.
340 . . .	3·48*d*.	480 . . .	4·80*d*.
350 . . .	3·57*d*.	500 . . .	5·01*d*.
360 . . .	3·66*d*.	520 . . .	5·22*d*.
370 . . .	3·75*d*.	550 . . .	5·55*d*.
380 . . .	3·84*d*.	580 . . .	5·88*d*.
390 . . .	3·93*d*.	610 . . .	6·21*d*.
400 . . .	4·02*d*.	640 . . .	6·54*d*.

The above prices are considerably below what is generally paid for Warping; this, to some extent, arises from the application of the stop-motion.

Blackburn Prices for Tape-Sizeing or Slashing,

Subject to a Reduction of 10 *per cent.*

In consequence of so many different lengths being made, the 100 yards has been added, it being so much simpler to calculate from, as the 100 yards' price only requires to be multiplied by the length, whatever it may be, removing the decimal point two figures more to the left.

Through some errors having crept into the original list, the following table will be found to differ slightly therefrom, as the calculations have been worked out strictly in accordance with the standard, irrespective of the prices given in the original list of 1867.

Taking 2,460 ends as a standard, deduct $\frac{3}{8}d.$ for every 50 ends below the standard, on 100 cuts of $37\frac{1}{2}$ yards.

Taking 2,460 ends as a standard, add $\frac{1}{2}d.$ for every 50 ends above the standard, on 100 cuts of $37\frac{1}{2}$ yards.

Fractional parts of 50 ends given in favour of the workman.

Ends.	1260 to 1310	1360 to 1410	1460 to 1510	1560 to 1610	1660 to 1710	1760 to 1810	1860 to 1910
	d.	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*
25 yards . .	13·	13·5	14·	14·5	15·	15·5	16·
$37\frac{1}{2}$,, . .	19·5	20·25	21·	21·75	22·5	23·25	24·
46 ,, . .	23·92	24·84	25·76	26·68	27·6	28·52	29·44
60 ,, . .	31·2	32·4	33·6	34·8	36·	37·2	38·4
100 ,, . .	52·	54·	56·	58·	60·	62·	64·

Ends.	1960 to 2010	2060 to 2110	2160 to 2210	2260 to 2310	2360 to 2410	2460 to 2510	2560 to 2610
	d.	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*
25 yards . .	16·5	17·	17·5	18·	18·5	19·	19·66'
$37\frac{1}{2}$,, . .	24·75	25·5	26·25	27·	27·75	28·5	29·5
46 ,, . .	30·36	31·28	32·2	33·12	34·04	34·96	36·19
60 ,, . .	39·6	40·8	42·	43·2	44·4	45·6	47·2
100 ,, . .	66·	68·	70·	72·	74·	76·	78·66

TAPE-SIZEING OR SLASHING—*continued.*

Ends.	2660 to 2710	2760 to 2810	2860 to 2910	2960 to 3010	3060 to 3110	3160 to 3210	3260 to 3310
	d.	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*
25 yards . .	20·33	21·	21·66'	22·33'	23·	23·66	24·33
$37\frac{1}{2}$ „ . .	30·5	31·5	32·5	33·5	34·5	35·5	36·5
46 „ . .	37·41	38·34	39·86	41·09	42·32	43·55	44·77
60 „ . .	48·8	50·4	52·	53·6	55·2	56·8	58·4
100 „ . .	81·33	84·	86·66	89·33	92·	94·66	97·33

Ends.	3360 to 3410	3460 to 3510	3560 to 3610	3660 to 3710	3760 to 3810	3860 to 3910	3960 to 4010
	d.	*d.*	*d.*	*d.*	*d.*	*d.*	*d.*
25 yards	25·	25·66'	26·33	27·	27·66	28·33'	29·
$37\frac{1}{2}$ „	37·5	38·5	39·5	40·5	41·5	42·5	43·5
46 „	46·	47·23	48·45	49·68	50·91	52·13	53·36
60 „	60·	61·6	63·2	64·8	66·4	68·	69·6
100 „	100·	102·66'	105·33'	108·	110·66'	113·33	116·

The preceding list is based upon medium counts of yarn. Extreme counts and sorts to be allowed for as per agreement.

BLACKBURN PRICES FOR LOOMING AND DRAWING.

Looming plain sorts . .	$3\frac{7}{16}d.$ per 1,000 ends.
Drawing plain sorts . .	$4\frac{7}{16}d.$ „ „
Drawing dhooties . .	$5d.$ „ „

Three and five-leaf twills, double warps, Yarns below 16's, fine reeds, and other special goods to be paid extra as per agreement. Jobbing or labouring to be paid by the hour.

The above prices are not subject to 10 per cent. reduction.

The above are the prices to be paid until the new list for looming and drawing is complete, which is now under consideration.

Blackburn Overlookers' Poundage.

Ordinary shirtings . .	1*s.* 4*d.* to 1*s.* 5*d.*
Jaconets	1*s.* 4*d.* to 1*s.* 5*d.*
Twills	1*s.* 4*d.* to 1*s.* 7*d.*
Staved work . . .	1*s.* 4*d.* to 1*s.* 8*d.*
Dhooties	1*s.* 4*d.* to 1*s.* 6*d.*
Dobbies	1*s.* 5*d.* to 1*s.* 10*d.*

The above are not subject to the 10 per cent. reduction, it having been previously deducted from the weavers' wages.

Burnley Prices for Winding.

The net standard price for winding at Burnley is $6\frac{1}{2}d.$ for 20 lbs. of 32's twist, and the following table is an arrangement therefrom:

Counts.	Price for 1 lb.	Counts.	Price for 1 lb.	Counts.	Price for 1 lb.
	d.		*d.*		*d.*
18's	·2157	46's	·4275	74's	·6576
20	·2285	48	·4463	76	·6754
22	·2435	50	·457	78	·6932
24	·2608	52	·4753	80	·7109
26	·2773	54	·4936	82	·7287
28	·2929	56	·5033	84	·7465
30	·3093	58	·5213	86	·7643
32	·325	60	·5332	88	·7820
34	·3401	62	·551	90	·7998
36	·3547	64	·5687	92	·8176
38	·3686	66	·5865	94	·8353
40	·3839	68	·6043	96	·8531
42	·3988	70	·6221	98	·8709
44	·4134	72	·6398	100	·8887

Burnley Prices for Looming and Drawing,

Recognized by the Twisters' Association.

NET PRICES FOR PLAINS.

Twisting	26's to 38's . . .	$3\frac{3}{4}d.$ per 1,000 ends.
,,	16's to 24's and 40's to 70's	$4d.$,, ,, ,,
,,	under 16's . . .	$4\frac{1}{2}d.$,, ,, ,,
,,	over 70's to 100's . .	$4\frac{1}{2}d.$,, ,, ,,
Drawing	up to 70's reeds . .	$6d.$,, ,, ,,
,,	70's to 100's . . .	$6\frac{1}{2}d.$,, ,, ,,

Burnley Overlookers' Poundage.

NET PRICES.

Plain cloths . .	1*s*. 1*d*. to 1*s*. 3*d*.
Twills . . .	1*s*. 3*d*. to 1*s*. 5*d*.
Jeanettes . .	1*s*. 3*d*. to 1*s*. 5*d*.
Dobbies . . .	1*s*. $4\frac{1}{2}d.$ to 1*s*. 9*d*.
Splits . . .	1*s*. 2*d*. to 1*s*. 5*d*.
Dhooties . . .	1*s*. 3*d*.
Drills . . .	1*s*. $3\frac{1}{2}d.$

The above matter constitutes the current Uniform List. Anything that may appear elsewhere in addition to it is by way of elucidation or comment, and not binding as an integral part of the agreement. Space will not allow of any comment or explanation.

The three following lists govern the other important sections of the weaving industry that do not come within the scope of the Uniform List.

Coloured Goods Weaving.

The following is the standard of the Colne district list (agreed to in 1890) for coloured goods, no change having taken place since then up to the end of 1893 :—

The standard upon which the price for plain and striped goods is based is as follows:—

Cloth.—28, 29, or 30 inches in width.

Reed.—52 to 64 both inclusive, or 26 to 32 dents per inch, two ends in a dent.

Length.—74 yards of warp, 36 inches to the yard.

Weft.—16's or any finer counts.

Price.—$1\frac{1}{2}d.$ per pick.

The standard upon which the price for checks is based is 70 yards of warp, $2d.$ per pick; in all other particulars the same as the standard for plain and striped goods.

The standard of the list of prices—agreed to in 1892, and still in operation without change—for coloured goods for Radcliffe and district is as follows:—

Cloth.—The list shall be based on cloth, 36 inches to the yard, and 100 yards long.

Reed.—56 reed, *i.e.*, 28 dents to the inch, and two ends in a dent.

Width.—27 to 30 inches measured on the counter in an unfinished state as it comes from the Loom.

Weft.—20's or any finer counts.

Shuttles.—Two.

Looms.—Drop box.

Warps.—Full (or hand) dressed or sectional warps.

Price per pick, per $\frac{1}{4}$ inch—$3{\cdot}4d.$ or $3d.$ and 2-5ths, as ascertained by wheel calculation with $1\frac{1}{2}$ per cent. added for contraction.

Velvet Weaving.

Velvet weaving is chiefly carried on in the Oldham district, and in this trade a somewhat different principle of arranging a standard list is adopted, the measurement being by weight of weft rather than by picks. The list was agreed to in 1888, but only the basis with allowances for weft came into operation in that year, the full list not being finally adopted until October, 1890. No change in the list has taken place since its introduction.

The basis of the list is as follows:—

45 and	49	looms	weaving	56's weft,	$7d.$	per lb.
50 „	54	„	„	„	$6\frac{13}{16}d.$	„
55 „	59	„	„	„	$6\frac{11}{16}d.$	„
60 „	64	„	„	„	$6\frac{9}{16}d.$	„
65 „	69	„	„	„	$6\frac{1}{2}d.$	„
70 „	74	„	„	„	$6\frac{3}{8}d.$	„
75 „	79	„	„	„	$6\frac{1}{4}d.$	„
80 „	84	„	„	„	$6\frac{1}{8}d.$	„
85 „	89	„	„	„	$6d.$	„

Whenever the looms are narrower than the above table $\frac{3}{16}d.$ per lb. shall be added for each range of 5 inches, and if broader $\frac{1}{8}d.$ per lb. shall be deducted for each similar range.

Quilt Weaving.

Quilts of various kinds are chiefly woven in the Bolton District, and there is in operation a price list mutually agreed to by employers and operatives through their associations. The list for Toilet and Marseilles quilts dates back to January, 1862, but in 1890 a list of prices for weaving Honeycomb, Alhambra, and Tapestry quilts was added thereto.

The list, or basis for Honeycomb quilts woven with one shuttle, is the shortest and simplest, and may be quoted as a specimen.

Counts of Reed reckoned 1 end per dent.	Width in Reed exclusive of Fringe.	Picks for $\frac{1}{8}$th of a Penny.	Counts of Reed reckoned 1 end per dent.	Width in Reed exclusive of Fringe.	Picks for $\frac{1}{8}$th of a Penny.
	Inches.			Inches.	
36	58	118	36	77	99
,,	59	117	,,	78	98
,,	60	116	,,	79	97
,,	61	115	,,	80	96
,,	62	114	,,	81	95
,,	63	113	,,	82	94
,,	64	112	,,	83	93
,,	65	111	,,	84	92
,,	66	110	,,	85	91
,,	67	109	,,	86	90
,,	68	108	,,	87	89
,,	69	107	,,	88	88
,,	70	106	,,	89	87
,,	71	105	,,	90	86
,,	72	104	,,	91	85
,,	73	103	,,	92	84
,,	74	102	,,	93	83
,,	75	101	,,	94	82
,,	76	100			

A 36 reed or 18 dents, being the standard, is made the starting point:—Two picks to be added for $\frac{1}{8}$th of a penny for a decrease of eight counts of reed, and deducting two picks for $\frac{1}{8}$th of a penny for an increase of eight counts of reed.

The above prices are for honey combs with fringes, Grecians, and honey combs without fringe, with a fret at the ends to have 10 picks extra for $\frac{1}{8}$th of a penny if there is not more than 12 inches of empty reed space; if there is more than a total of 12 inches of empty reed space, to be paid as fringed honey combs.

Coloured stripes in warp $\frac{1}{8}$th of a penny per quilt extra.

Coloured border in warp and weft $\frac{1}{4}d.$ per quilt extra.

Brocade stripes, 10 per cent. extra.

Any of the afore-mentioned quilts, if woven with a second shuttle (drop box at one side only), to be paid

10 per cent. extra, if woven with a third shuttle (drop box at one side only) to be paid 20 per cent. extra.

Honey comb quilts woven with two shuttles (pick and pick) to be paid 20 per cent. extra to one shuttle price, three shuttles (pick and pick) 30 per cent. extra to one shuttle price.

Specialties in Looms.

It will have been obvious that in tracing the development of the loom in the preceding pages, it was impossible to follow the subject into its side issues. To have done so would have required almost another volume. These issues have resulted in the invention and construction of specialties in looms for almost every purpose and requirement conceivable in connection with the textile industries. But they cannot be described on account of the exigencies of space. Still, as the reader may desire to know where such looms may be obtained, the following notes on the productions of the leading loom makers may be of service in directing the quest.

Naturally loom making flourishes most in the great weaving districts of Lancashire, and it is in the midst of these that the principal loom-making establishments are found.

Blackburn is a chief centre of the weaving trade of Lancashire, and it has four important machine shops making weaving and preparation machinery.

Messrs. Henry Livesey, Limited, have a large and growing establishment, and make looms from 24 to 140-inch reed space in width. Besides making all classes of looms suitable for the Lancashire trade, they make many varieties and specialties suitable for home and foreign markets, and with the adjuncts necessary for the production of plain and figured fabrics in the various types of tappet, dobby, and jacquard appliances. Checking looms with rising and revolving boxes, and with the

best and most recently invented motions, including Eccles' patent. Winding, warping, size-mixing, sizeing, and all the machinery etceteras of the preparation department are also included.

Messrs. John Dugdale and Sons is an old and well known firm making the looms usually required in the Lancashire weaving districts, and for districts abroad engaged in the production of similar fabrics. The firm also makes a number of specialties for various purposes, including the Wright Shaw check loom described in detail in the preceding pages. Preparation machinery of a high quality is also included in their production.

Messrs. William Dickinson and Sons is another well known and old-established firm of loom makers, whose founder was the inventor of the "Blackburn loom," otherwise known as the side-pick loom, which is the most extensively used of all picking methods. There are more power-looms of this type than of all others put together. This firm makes a good loom suitable for all classes of Lancashire cotton goods. It also makes winding, warping, and sizing machinery with the latest improvements in details.

Messrs. Willan and Mills is another well known firm of loom makers which has been in the business for about half a century. This firm makes the several varieties of looms in request by the Lancashire trade, and for markets abroad producing similar classes of goods. Plain, twill, check, and looms for the production of figured goods, with all sorts of adjuncts for the production of variety of effects are included. Also preparation machinery.

Burnley is another great centre of weaving in Lancashire, the productions of which differ somewhat from those of Blackburn. The specialty loom of this district is a light, narrow, quick-running loom, making about 240 to 260 picks per minute, and mainly employed for the production of the light printing cloths for which the town has a great reputation.

Messrs. Butterworth and Dickinson, a loom-making firm in this town, have attained a high reputation for their weaving machinery. They make all descriptions of looms for cotton, linen, worsted, woollen, and silk goods in all widths, and with loose or fast reeds; and revolving and drop-box looms, including the "Eccles patent." The preparation machinery includes several specialties, amongst which may be mentioned Bethel's sectional warping machine previously described in detail, warp balling machines, and ball warp beaming machines; and with the sizing machine several of the firm's patented improvements.

Messrs. Howard and Bullough, Accrington, the great cotton-spinning machinery makers, make preparation machinery for the weaving department. In this department they have many important specialties in inventions relating to warping and sizeing machines, especially the latter. Some of these have been already described in detail in the preceding chapters. This firm also supplies looms of all kinds.

The town of Bury is the centre of another great weaving district, differing considerably from the two already mentioned. The fabrics produced in this district are light and heavy woven coloured goods, cotton velvets, velveteens, cords, moleskins, cotton and union ticks, and many varieties which cannot be enumerated. The looms for these classes, which form a large variety, are mainly made in Bury and neighbourhood.

It is in Bury that the most remarkable specialties in looms are made, these being for almost every conceivable purpose, and for every specialty in textile fabrics required in all the textile industries, both in and outside of the cotton trade.

The firm of Messrs. Robert Hall and Sons, Bury, Limited, besides all the ordinary types of looms, make the following specialties for cotton fabrics:—Sponge cloth and cross-weaving looms; needlework netting looms; cotton belting and hose-pipe looms; cotton

blanket and sheeting looms; canvass looms; Alhambra quilting, toilet, and pique looms; Marseilles quilt looms; corset cloth looms; pick-and-pick looms; drop and circular box looms; cotton trousering looms; dobby and jacquard looms; candlewick and tape looms; sail-cloth looms; sugar-bag looms; Turkish towel looms; and paper machine cotton-felt looms. This firm also make all sorts of specialties in looms for the other textile industries. Preparation machinery in numerous specialties is also produced in their establishment.

Messrs. Hacking and Co., of the same town, make all kinds of specialties in looms required to make a somewhat lighter type of goods. These include looms for weaving all kinds of fustian goods; for strong linen and cotton goods; nankeens; drills; cotton, union, and linen ticks; huckabacks; regattas and drabbetts; under and overpick looms for light and heavy ginghams and checks; handkerchiefs; plain and fancy silk goods; drop and circular box looms; looms for leno, gauze, and cross-bordered goods; lappet, pick-and-pick, and dobby and jacquard looms for all kinds of figured goods.

Messrs. Platt, Brothers, and Co., Limited, Oldham, are extensive makers of high class looms chiefly for the heavy classes of cotton goods. They have also a recently-invented specialty, a loom for weaving coloured bordered goods with grey or different coloured centres. The borders are filled with wefts of a different colour from that of the centre. Briefly described, the loom may be called a triple loom, consisting of a wide centre loom of the usual type, having a ribbon loom attached at each end of the centre lay. The junction of the borders with the centre cloth is easily effected. This loom was fully described and illustrated in the "Textile Mercury" of August 11th, 1894.

Messrs. Smith Brothers, Heywood, make looms similar to those made in Bury.

Messrs. Richardson, Tuer, and Co., make the classes of looms generally in use in the South Lancashire district

for weaving plain and fancy fabrics, such as heavy toilets, quilts, fustians, cords, moles, velvets, heavy and light checks, ginghams, and twills. Also the adjuncts suitable for such looms, pirn winding machines, etc.

So varied are the requirements of the manufacturing division of the cotton trade that they have led to the subdivision of the business of making the necessary machinery in several instances. These are in: winding machinery, loom temples, jacquards, shuttles, pickers, healds, reeds, and the leather furniture of looms. Sizeing flours and chemicals also form important adjuncts.

Mr. Joseph Stubbs, Manchester, is a well known maker of every description of yarn winding and reeling machinery, including a great number of specialties for single, double, and many fold thread winding, gassing, bundling, etc.

Messrs. John Horrocks and Sons' is an old-established firm of winding machine makers, producing stop-motion drum doubling winding, re-winding, and cross-winding machines, and cup, quill, and pirn winding machines.

Messrs. Brooks and Doxey, makers of cotton-spinning machinery, have also some specialties in winding machinery, amongst which may specially be mentioned the Hill and Brown patent winding machine for winding yarn upon paper tubes and dispensing with flanged bobbins.

Mr. Thomas Coleby's patent reels and bundling press have already been described.

Messrs. J. and T. Boyd, Shettleston Ironworks, near Glasgow, is another eminent firm, making all classes of winding and twisting machinery, including numerous specialties for the cotton and other textile industries.

There is one indispensable adjunct of the loom which we find has not received the notice it deserves in the preceding pages. This is the "temple," the instrument which keeps the cloth expanded during the weaving process to a width as nearly as possible coincident to that of the warp in the reed. This is necessary to prevent the edge threads of the warp being broken, or pulled in so as to narrow the

cloth by the drag of the weft as it is being inserted. There are a very large variety of these temples, as will readily be conjectured from the immense variety of fabrics made. The manufacture of these has also become a special business.

Messrs. Lupton Brothers, Accrington, are large makers of temples, having several hundred varieties for the cotton and the other textile industries. The types are mainly the roller, ring, segment, and star kinds, with numerous modifications in each.

Messrs. J. Blezard and Sons, Padiham, is an old-established firm of temple makers, making numerous varieties for the various branches of the textile trades.

The Jacquard is an important adjunct of fancy weaving, and the making of these has also developed into an independent business. The principal makers are: Messrs. Devoge and Co., Manchester, Mr. James McMurdo, Manchester.

There are also adjuncts to the Jacquard machine, namely, card cutting and card lacing machines. Messrs. William Ayrton and Co., Manchester, make these machines. Messrs. The Singer Manufacturing company, the great sewing machine makers, make a card lacing machine.

The other special businesses that have grown out of efforts to supply the ever-increasing wants of the principal trade do not call for detailed notice.

The particular mention here made of the leading firms is due to and is given in recognition of the facilities they have accorded and the information they have given to the writer in the preparation of this work, which is now committed to the classes of readers for whom it has been mainly written, in the hope and trust that the information given will be found both interesting, instructive, and suggestive of further improvements.

THE END.

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